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British Hydromechanics Research Association

THE British Hydromechanics Research Association, whose laboratory was the first industrial building to be erected at the new town of Harlow three years ago, held its open days on Thursday and Friday of last week. It has since been considerably expanded, its staff now totalling forty and its present income of £50,000 per annum having been trebled. The Association was started by manufacturers of hydraulic machinery and their interests are represented by the fundamental work on the flow in centrifugal pumps and fans, reciprocating pump valves, and on seals and gland packings. The experimental side of this work, which involves the measurement of pressure and the direction and velocities of flow inside moving machinery, is difficult, but it is hoped that significant progress has been made. Two techniques are of particular interest—one being multiple flash photographic method in which nine high intensity flashes are fired off in a controlled sequence at time intervals of half a millisecond, so enabling the passage of tracers through a transparent pump to be photographed. The other technique, which is thought to be new in this country, is the use of both moving and stationary hot wire anemometers in air models, in which the relatively high frequency of the pump blade movement can be recorded without the usual increasing attenuation with speed. An electronic controller maintains the hot wire at a constant temperature and records the automatically varying heating current on an oscillograph. Work on civil engineering structures included the best layout of large pump suction wells to prevent the entrainment of vortices and models of flood spillways for large dams, where it is important to avoid cavitation with consequent damage to the concrete. The hydraulic transport of coal forms one of the most important and conspicuous items of research in progress, work on which has already been widely published. Various test rigs using pipes up to 6in diameter with arrangements for measuring all the variables were shown. It was now possible to estimate pressure drops for any practical conditions to within 20 per cent and it was stated that many applications of fluid transport merely awaited the development of suitable machinery. Its work in this direction was demonstrated. In cases where heads up to about 500ft are required, centrifugal gravel pumps were satisfactory but for higher heads—such as for raising coal from the pit bottom, a possible method was to feed the coal into high pressure water. An experimental feeder capable of handling 20 tons per hour against a head of 1000ft was shown, and a small transparent model was used to illustrate the feeder mechanism and to circulate small coal through a 100ft transparent pipe.

British Iron and Steel Research Association

THE tenth annual report of the British Iron and Steel Research Association has appeared this week. It contains a record of the work carried out, during 1953, by the Association's eight main divisions, prefaced by a general report from the council. A major event of the year, which is noted in the report, was the opening by H.R.H. The Duke of Edinburgh of the new laboratories at Sheffield, a description of which was published in our issue of November 27, 1953. The report comments that the extra research facilities at Sheffield, coupled with the added cost of the upkeep of the laboratories, make it increasingly difficult to contain the Association's expenditure within the bounds of its income and, at the same time, to continue to set aside a small sum towards reserves for future developments. Apart from the 200 or so projects in the Association's current research programme there are many others that could well be started if sufficient funds were available. In particular, the report says, there is special need to intensify research on design of steelworks plant as it is felt that industry has for too long been dependent upon American design. From the sterling counterpart funds allotted by the U.S. Treasury under the provisions of the Mutual Security Act, grants totalling £25,700, spread over three years, have been approved for investigations on productivity in the steel industry, the improvement of control design, the organisation of the flow of technical information into and within the industry, and on advisory services. Because of these additional investigations, the Association's operational research section has been increased. Another matter mentioned in the report is the special attention given to accelerating the commercial development of a few of the more promising research projects, the most notable, it is stated, being the formation of a group of member firms to build and operate a small-scale commercial plant for the continuous casting of steel. It is also noted in the report that the commercial development of automatic gauge control for strip rolling has been passed to one of the Association's member firms.

Technical Colleges and Industry

LAST week, the Federation of British Industries held a conference, at Ashorne Hill, Leamington Spa, on "Technical Colleges and Industry." It was attended by over eighty industrialists and fifty-five educationalists, many of them being principals of technical colleges. Sir Norman Kipping, Director-General of the Federation of British Industries, presided over the conference, the subjects discussed including what industry expects from the technical colleges, the contribution of the technical colleges to technological education, the broadening of technical education, management studies in the technical colleges, and the changing pattern of part-time and full-time courses in the technical colleges. In an introduction to the proceedings, Dr. Percy Dunsheath, chairman of the F.B.I. education committee, said that, in the interest of the national economy, industry must apply science in the production of goods and services at an ever increasing rate, and few would deny that in this matter our technical colleges constituted a very important factor. On the one hand, industry could not continue to thrive without the great contributions which were made in the training of its personnel by the colleges, and on the other, without a live industry there would be no need for the colleges. The past decade, Dr. Dunsheath suggested, had been unique in the amount of interest displayed in this country in the development of technical education. Never before had there been so many opinions canvassed on the need for improvement and on the best ways of achieving the result. But, Dr. Dunsheath added, there was still much to be done in bringing to a focus the wealth of ideas now available from the many discussions.

Iron and Steel Institute Awards

THE Iron and Steel Institute has announced the award of the Bessemer Gold Medal for 1954 to Dr. T. P. Colclough, in recognition of his distinguished contribution to the development, in theory and practice, of the manufacture of iron and steel. Dr. Colclough is technical adviser to the British Iron and Steel Federation. The Sir Robert Hadfield Medal for 1954 is awarded to Dr. A. H. Leckie, technical officer to the Iron and Steel Board, in recognition of his valuable contributions to research in steelmaking. Mr. G. R. Bish, of Enfield Cables, Ltd., is to receive the Andrew Carnegie Silver Medal for his report on "The Deformation of Austenite in Relation to the Hardness Characteristics of Steel." The Williams prizes for 1953 have been won by Mr. A. H. Norris, of John Lysaght, Ltd., Scunthorpe, for his paper on "Soaking Pit Practice at the Normanby Park Steelworks," and to Mr. E. R. S. Watkin, of Appleby-Frodingham Steel Company, for his paper on "Railway Traffic of the Appleby-Frodingham Steelworks." The Ablett prize has been gained by Mr. F. Starkey, of Buckley and Taylor, Ltd., for a paper entitled "Guides and Strippers for Modern Rod and Bar Mills." These medals and prizes are to be presented at the opening session of the Iron and Steel Institute's annual general meeting on Wednesday, May 26th.

Mining and Metallurgy Award

THE council of the Institution of Mining and Metallurgy has announced the award of the Institution's gold medal to Mr. Essington Lewis, C.H. Mr. Essington Lewis was the president of the fifth Empire Mining and Metallurgical Congress, which was held last year, and the award has been made in recognition of his long and distinguished services to the mining and metallurgical industries of Australia. Mr. Lewis has been a member of the Institution of Mining and Metallurgy since 1918. He began his career as a mining engineer with the Broken Hill Proprietary Company in 1904 and has been associated with that company ever since. Mr. Lewis was appointed general manager in 1921 and managing director five years later. In 1950 he was appointed chairman of Broken Hill Proprietary Company, Ltd., and of many of its subsidiaries. Mr. Lewis is also chairman of Stewarts and Lloyds (Aust.) Pty., Ltd., and British Tube Mills (Aust.) Pty., Ltd. In the second world war, Mr. Lewis served as Australia's director-general of munitions and director-general of aircraft production. He was created a Companion of Honour in 1943.

Canadian Pacific Railway

IN the course of his address at the annual general meeting of the Canadian Pacific Railway Company, which was held in Montreal on May 5th, Mr. W. A. Mather, the president, said that the largest single factor in achieving efficiency and low cost operation had been the substitution of diesel for steam power on certain lines. The 70,000,000 dollars already expended on diesel locomotives and facilities had led to a reduction in operating expenses of about 12,000,000 dollars a year. Although, Mr. Mather commented, experience indicated that the greatest savings in any programme of improvement were usually achieved from initial installations, room existed for further substantial economies from the substitution of diesel for steam power. He went on to say that the statistical record gave striking evidence of the strides towards increased efficiency made possible by the capital expenditures undertaken. Whilst in 1953 the total traffic volume exceeded that of twenty-five years ago by 50 per cent, there was a reduction of almost 10 per cent in the required number of man hours. Operation of longer trains, together with greater average capacity of freight wagons and increased train speeds, had resulted in the attainment last year of a new record in the number of gross ton miles per freight train hour. Nevertheless, Mr. Mather continued, increases in wages and materials prices had been such that, notwithstanding improved efficiency and high traffic volume, the railway's financial results had worsened to the extent that the level of net earnings had been reduced to almost half of that of twenty-five years ago. He thought that the time was long overdue for the railways to be permitted the greatest possible freedom in pricing their services.

Some Recent Swiss Hydro-Electric Schemes

No. IV—(*Continued from page 593, April 23rd*)

The principal elements of the Mauvoisin scheme in the Val de Bagnes were briefly outlined earlier in this series and its general layout as related to the Grande Dixence Scheme was described. A more detailed account of the scheme is given here.

THE Société des Forces Motrices de Mauvoisin S.A. is developing a concession for hydro-electric power generation in the Valais canton, by the construction of a major project on the Dranse de Bagnes River. The concession is held for eighty years from the time when the power stations are put into service or, at the latest, from December 31, 1956. This company was formed, as its name indicates, expressly for the development of the Mauvoisin concession, and the holding company controlling it is Electro-Watt (Enterprises Electriques et Industrielles) S.A. of Zurich, which is a large Swiss concern whose activities include the management of large hydro-electric projects. In general outline, the Mauvoisin scheme has already been described, and figures for its estimated power production, reservoir capacity, and so on, have already been given in No. I of this series of articles. The principal interest of the scheme lies in the dam, which will form a large seasonal reservoir at the head of the system ; but before describing that structure, mention should be made of the other elements of the scheme, principally the two power stations. Some of their leading particulars are shown in Table VI.

TABLE VI—*Power Stations of the Mauvoisin Scheme*

	Gross head (metres)		Rated flow (cumecs)	Installed capacity, MW	Turbo-alternator sets
	Max.	Min.			
Fionnay	472·5	307·5	23*	85 (at max. head) 55 (at min. head)	2 vertical Francis (ultimately three)
Riddes...	1015·7	1003·2	28·75	225	5 horizontal Pelton

Annual production of energy in millions of kilowatt-hours : Summer, 166 ; winter, 595 ; total, 761

* This figure may be increased to 34·5 cumecs when the third turbo-alternator set is ultimately installed at Fionnay.

The intake to Fionnay (Mauvoisin) power station (item 5, legend to Fig. 14) will be 90m upstream from the dam. From this intake a pressure tunnel will lead to the surge and pressure shafts ; this tunnel operates under a head of 170m to 200m. The pressure shaft is inclined at 80 per cent ; it is 443m long, has an internal diameter of 2·4m, and is lined with steel with a thickness of 17mm to 32mm. Above the junction of the pressure shaft and the pressure tunnel the inclined line of the pressure shaft is continued by the surge shaft, whose diameter is 4m and length 317m. There is an access tunnel at the top of the surge shaft and also a winch chamber. At its bottom end, the pressure shaft is continued horizontally, with its steel lining varying between 23mm and 40mm in thickness, for a length of 69m. Three branches lead off it here, one to each of the three valves controlling the flow to the turbines. Rotary valves are to be installed, 1200mm in diameter, with double seals in their construction. An access tunnel for construction of the power station connects with the end of the pressure shaft and with the valve chamber, thus giving an emergency exit for water in the event of a valve failure. The rotary valves are described in greater detail in the paragraphs below.

There are to be two identical vertical Francis turbine sets in the power station, with a total installed capacity of 85MW ; space for a third set is provided. The gross head will vary between 472·5m and 307·5m, which is the highest head employed up to now for Francis machines. The rated flow is to be 23 cumecs with two sets installed, but will be increased to 34·5 cumecs for the total of three sets. The layout of the power station follows closely along the lines adopted for other underground designs. In this case, however, there are separate bar and cable tunnels leading to an outdoor transformer and switchgear installation. Servicing of machines can also be carried out in a space reserved for this purpose in the outdoor switchyard. The tail-race tunnels from each of the three turbines meet below an expansion chamber 9m in diameter and 19·3m high, also excavated out of the rock, and the tail-race tunnel then passes under the bed of the Dranse River to the tail-race basin. Its total length is 247m and its diameter 3·43m to 3·3m. The compensation basin is excavated in a comparatively flat area in the bottom of the valley, and has a capacity of 180,000 cubic metres. As was mentioned earlier, this basin is to have a connection with a similar one to be built for the Fionnay (Dixence) power station, and water may be exchanged between the two schemes at this point, or may be discharged back into the River Dranse. There is also an intake with the usual provision for the removal of gravel and sand, on the Dranse just upstream of the Mauvoisin scheme's compensating basin, and leading into it. Thus the river flow from the catchment area of 21 square kilometres between the dam site and the power station may be collected here and added to the flow diverted to the second power station of the scheme near Riddes. This intake will also serve to supply water to the first three turbo-alternator sets at Riddes, which it is planned will be in operation before the upper works are completed.

Riddes power station will be a surface structure, built on the left bank side of the Rhone valley. It will eventually contain five horizontal generating sets, each driven by two Pelton turbines, totalling 225MW and operating under a gross head of 1076m. The pressure tunnel from Fionnay will be 14,720m long and 3·25m to 3·10m in diameter, ending in a surge shaft 3·1m in diameter and 76m in height, connected by a throat to the tunnel and having an expansion chamber, with access from the surface, at the top. Downstream of the surge shaft there is a short section of inclined pressure tunnel, 257m long and 2·7m in diameter, ending in a valve house where the flow bifurcates, and is then carried down to Riddes power-house by two penstocks. The penstocks are each 1768m in length, 1·7 reducing to 1·5m in diameter, and with pipe thicknesses from 12mm to 45mm. The total weight of steel in them is about 4200 tonnes, with hydrostatic pressures from 9 kg/cm² to 103 kg/cm². Flow is controlled in the valve house at the top of the penstocks, where there are two 1750mm butterfly valves in series on each of the two pipelines. At the power station the two penstocks are continued parallel to the machine room, with branches, each forming an acute angle with the main pipe, leading off to each turbine. There are five horizontal turbo-alternator sets, each driven by two Pelton turbines. The maximum length of the distributing pipes at the lower end of the penstocks is 119m, and their diameters reduce from 1·5m (the full penstock diameter) to 0·7m in the last length, with steel thicknesses of 48mm to 23mm. There are ten spherical valves, each of 700mm in diameter and with double sealing, to

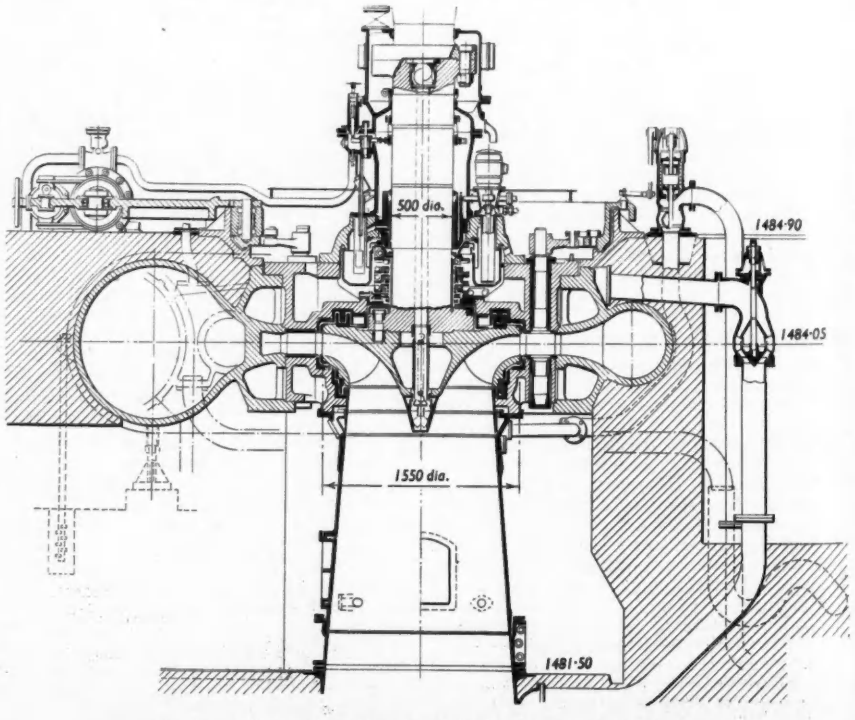


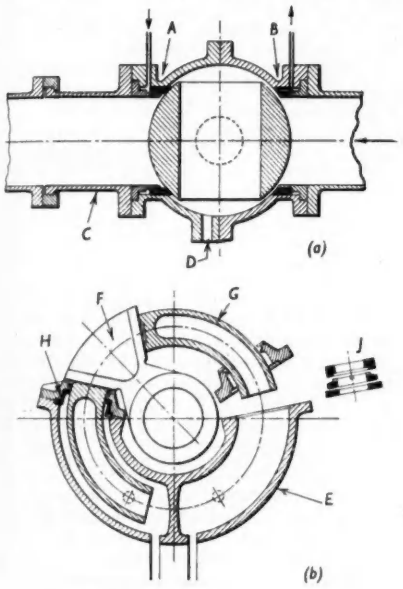
Fig. 12—Cross Section of Francis Turbine at Fionnay Power Station

control the flow to each turbine. The tail-race canal from the power station to the River Rhone is 1·1km in length and consists of a double reinforced concrete culvert, built by cut-and-cover methods, comprising two rectangular culverts, each 2·6m wide and 2·0m deep; the tail-race culvert is about 477m above sea level at the power station, which may be compared with the top water level at Mauvoisin reservoir, which is 1960m above sea level.

Electrical and Mechanical Plant

The Francis turbines at Fionnay, as was mentioned above, are to operate under an exceptionally high head. These machines will each be of 62,800 h.p. (in Continental units, which are approximately equal to the British horsepower) with a maximum gross head of 472·5m (1509ft), operating at 750 r.p.m., with a maximum flow of 11·5 cumecs. Their specific speed is 20·2 (in British units).

The makers point out that the conditions under which these turbines operate are unusually severe, not only on account of the high head, but also because of the wide variation in head. The net heads will vary from 455m to 284m, the power of each set being 35,300 h.p. under the minimum head. The turbine runner is of cast stainless steel and operates with a minimum pressure head in the draught tube of 3·5m. The runaway speed of the turbine is 1400 r.p.m. One of the turbines is shown in cross section in Fig. 12.



(*a*).—Double Sealing Valve.
A—Normal service seal (closed).
B—Reserve seal (open).
C—Removable pipe section.
D—Leakage water drain.

(*b*).— Annular Piston Actuating Gear.
E—Housing.
F—Lever on valve trunnion.
G—Annular piston.
H—Piston packing.
J—Piston packing detail.

Fig. 13—Rotary Valve with Double Seat

Each of the turbines at Fionnay is to be directly coupled to a three-phase alternator of 60MVA capacity, generating at 10·5kV, 50 c/s. There are two sets of transformers of 60MVA capacity (each comprising three single-phase elements), situated in the open air, transforming from 10·5kV to the transmission voltage of 225kV, and there are to be two 225kV lines to Riddes. There will also be two auxiliary turbo-alternator sets in the power station, each one of 800kVA, and Pelton wheel driven.

At Riddes power station the five principal machine sets will operate at 500 r.p.m., each absorbing a rated flow of 5·75 cumecs to give 64,600 h.p. under a net head of 952m. The alternators are rated at 67MVA, and generate at 10·5kV, 50 c/s, three phase. With four sets in service the net head will be 952m, but with only one set in service it will rise to 1005m, and the power to 68,400 h.p. Each of the two turbines of each set is overhung. The runners are each cast of stainless steel in a single piece; their nominal diameter is 2·45m. There is one jet for each turbine, with inlets of relatively large radii of curvature, giving a speed of 9·21m per second to the jet. The jets are controlled by deflector and by spear. Two "crucifix" guides, serve to direct the water of the jet, as well as the spear; one of the guides is placed near the junction of the inlet elbow at the rear end of the spear, and the other close to the nozzle.

There are to be two 800kVA auxiliary sets, as at Fionnay, and five 67MVA banks of transformers composed of single-phase units, transforming 10·5/225kV. The switching station is to accommodate the two incoming lines from Fionnay, and two lines going towards the north of Switzerland, two to the Haut Valais and two to the Bas Valais.

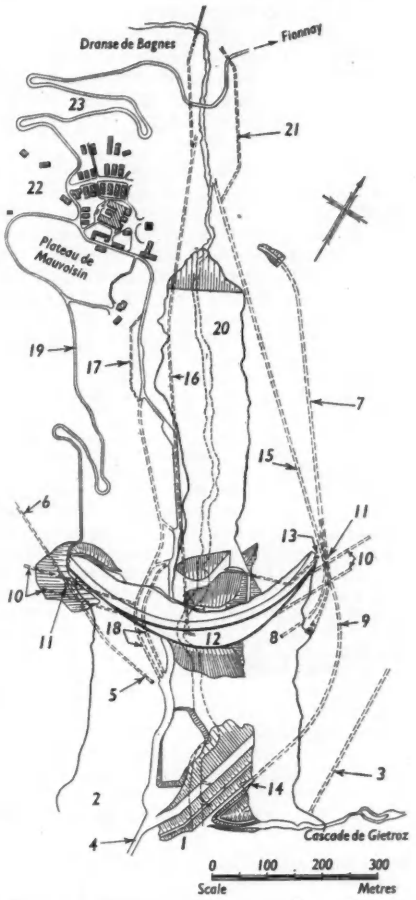
The double-sealing rotary valves at the turbine inlets of the two power stations are typical of valves that have been installed in a number of recent Swiss hydro-electric power stations, their principle of operation being shown diagrammatically in Fig. 13 (*a*). The normal sealing ring, operated by hydraulic pressure, is shown closed, whilst the second sealing ring on the upstream side of the valve is shown open. This additional sealing ring gives an added degree of security to the valve so that in several installations, the makers state, it has been possible to dispense with a second emergency valve which would otherwise be necessary. The removable pipe section shown in the diagram allows replacement of the sealing ring without dismantling the valve. The hydraulic actuating gear for these valves is shown diagrammatically at (*b*) Fig. 13, from which it will be seen that annular pistons are employed. The makers consider this method to show several advantages over the more normal arrangement of hydraulic cylinders with a rectilinear stroke, transmitted through rod and link assemblies or rack and pinion to the valve. In this case the pistons of the hydraulic cylinders are curved (as in (*b*) Fig. 13) and their movement is transmitted directly to the valve, for they are rigidly connected to the operating arm of the valve trunnion. Thus the intermediate rod and links or rack and pinion are eliminated. One piston opens and one closes the valve, and the gear is tight in all positions of the valve. The piston packings, *H* and *J*, may be noted. The makers point out that the pistons and packings are subject to moderate sliding stresses and not to guide pressures of any kind, but only the pressure of the hydraulic fluid. The pistons can be treated to protect them from rust, and the packings, it is claimed, are subject to little wear and are positioned where replacement is easy. The valve is also insensitive, it is pointed out, to a sandy water supply in the hydraulic system, for the sand settles at the bottom of the servo-motor and does not reach the packings.

Mauvoisin Dam

The form of Mauvoisin dam and the various constructional works at the site of the dam may be seen in Figs. 14 and 15; Table VII gives some further information. The dam was designed by Professor Stucky by a method which, unlike the theoretical approaches developed in other countries, is based on the modular ratio of the rock and the concrete. The layout of the plant and the various tunnels is rather complicated. For clarity a list of the tunnels at the dam site, which may be identified by the numbers referring to Fig. 14, is given first.

(*a*) The intake tunnel to Fionnay power station. This tunnel will carry a flow of 23 cumecs, under pressure, and starts at the intake structure on the left bank just upstream of the dam (numbers 5 and 6).

(*b*) The diversion tunnel, for carrying the flow of the River Dranse during construction,



1—Cofferdam, top level 1803·5m above sea level.
2—Future reservoir, useful storage capacity 177×10^6 cubic metres.
3—Tunnel bringing water to reservoir from right bank aqueducts.
4—Access road to aggregate quarry.
5—Intake to Fionnay power station (capacity 23 cumecs), controlled by two 2·7m diameter butterfly valves in series.
6—Pressure tunnel to Fionnay power station, 4780m long, 3·1m diameter, head 170 to 200m.
7—Tunnel for middle level scour outlet and spillway.
8—Middle level scour outlet.
9—Spillway.
10—Grouting tunnels.
11—Operating chambers for valves.
12—Arch dam, 227m high.
13—Lift.
14 and 15—Intake and tunnel for diversion of stream flow during construction, and forming bottom level scour outlet of reservoir.
16—Drainage tunnel serving constructional area at dam.
17—Access road to dam (lower and middle levels) and quarry.
18—Tunnels under left bank abutment for access road.
19—Access road to crown of dam.
20—Spoil tip: top level 1797m.
21—Adit for access.
22—Workers camp.
23—New road.

Fig. 14—Constructional Works at Mauvoisin Dam Site

is under the right bank, and will form the scour pipe of the completed reservoir works (numbers 14 and 15). The tunnel intake just upstream of the cofferdam, and the valve chamber (11) close to the main dam, may be noted. This tunnel is 1149m long, sloped at 4·9 per cent, and is large enough for a flow of 140 cumecs. The valves controlling its use as a scour tunnel were due to be installed by this winter.

(*c*) Access tunnels for the roads leading to the lower levels of the dam and to the quarry.

These tunnels will be plugged on completion of the work (number 18).

(*d*) A system of grouting tunnels at various levels (number 10) to connect with inspection tunnels in the completed dam.

(*e*) A tunnel (number 16) for draining the excavation, during construction. This tunnel will start from a shaft situated in the bottom of the excavation for the dam, and will drain the excavation area by gravity. The tunnel will also serve to carry away cooling water during concreting and the water used for washing the aggregates. The concrete will be cooled with the water flowing from a small glacier—Giétroz—situated just upstream of the dam on the right bank. The flow from this glacier falls just downstream of the cofferdam, so a reinforced concrete culvert has been built to carry it to the tunnel (number 16) or to the cooling pipes, as required.

(*f*) Tunnels bringing additional waters to the reservoir. The aqueduct system of the scheme was described in article No. I. Only one of the aqueduct tunnels is shown here on the right bank (number 3).

(*g*) Excavation tunnels. These tunnels are not shown on the drawing. The "funnel" method of excavation is employed where spoil is tipped into a shaft or shafts at various levels and recovered from a tunnel at the bottom.

(*h*) Tunnels to house conveyor belts for the concrete aggregates. These tunnels are also not shown in the diagram and their significance is explained further on.

There will also be a spillway built in the rock near the right bank abutment of the dam, at the crest level.

Cement is being brought by bicable ropeway from Le Châble ; the capacity of the ropeway is 60 tonnes per hour and it is almost 14km in length. Aggregates are excavated from a large deposit about 30m thick and covering a large area in the bottom of the valley (the Plaine Torrembé) about a kilometre upstream from the dam site. The quarrying is to be carried out in stages with successive lowering of the bed of the Dranse to allow working in the dry. The excavated material is transported by "Euclids" or similar heavy vehicle through the road tunnels mentioned in the list above, to the washing, crushing and screening plant built on the left bank just downstream of the dam. The cross section through the dam (Fig. 15) shows that spoil from the excavation is being tipped in the valley bottom downstream of the dam to form a flat area at a level of 1797m. The aggregate plant is built at about this level. At a later stage of the work (after 1955) water will be stored in the reservoir, before the dam is built to its full height. It will therefore be necessary to accumulate a stock of aggregate, which, it will be recalled, is quarried from the bottom of the future reservoir, before the road tunnels are sealed preparatory to storing water. This stock (about 3,000,000 cubic metres) will gradually be built up on the plateau formed from the excavation. It will then be passed through the aggregate plant as required, and elevated to the concrete batching and mixing plant, which is situated at a level of 1946m (almost the crest level of the dam), to facilitate emplacement of the concrete by cableway. As a protection against avalanches the conveyor system for elevating the aggregate will be installed in a system of four tunnels (which were mentioned in the list above) forming a zigzag path up to the batching plant. The washing, crushing and screening plant is of 400 cubic metres per hour capacity. The concrete is to be mixed in a concrete station with three 3-cubic-metre mixers, with the customary weigh-batching arrangements. The first part of the dam to be built will form a road close to the concrete plant, over which the concrete trucks will travel to take the concrete to the cableways. The concrete is to be poured in blocks 18m square and will be cooled by glacial water running through embedded cooling pipes.

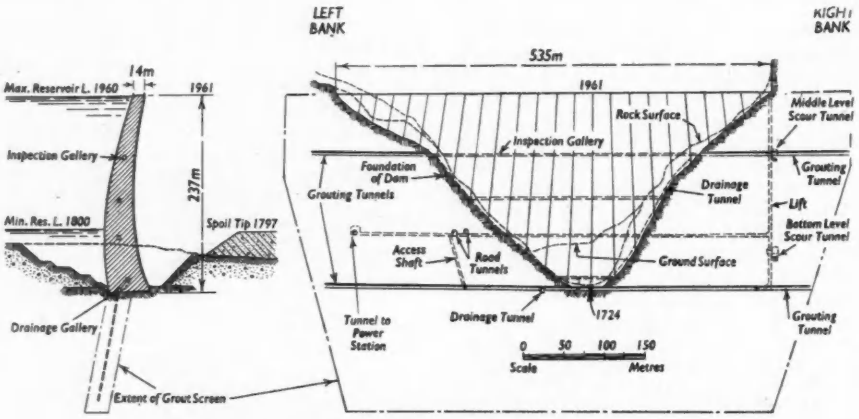


Fig. 15—Cross Section and Developed Elevation of Upstream Face of Dam

The concrete mix is to contain 160km to 250km of cement per cubic metre, with aggregate sizes of 0–3, 3–10, 10–30, 30–60, and 60–120 in millimetres and a water cement ratio of 0·48, with a specified 90 day crushing strength of 270 to 380 kg/cm², measured with 30cm test cubes. The necessity for additives or air entrainment is still being investigated. A concrete laboratory will be set up at the dam site to keep a constant check on the quality of the work. There are to be three cableways for placing the concrete, each of 20 tonnes (or 6 cubic metres of mixed concrete) capacity.

About a hundred working days are available for concreting during the year, and it is planned to work with two ten-hour shifts each day, to give a maximum daily output of some 6000 cubic metres of concrete.

Excavation at the dam site is a difficult process. The valley is massive and steep, as may be deduced from its suitability for an arch dam 237m high, and there is danger from avalanches, particularly on the right bank. An inclined tunnel, with a slope of 47 deg., was first excavated under the left bank, and "funnels" for tipping the spoil into it were constructed at various levels. Excavation could then be carried out at each of these levels, and the spoil recovered at the bottom. On the right bank such an inclined tunnel is being used to carry out the top part of the excavation, where protective walls are to be built in reinforced concrete, as the danger from avalanches is considerable. The lower part of the excavation is to be done by blasting. An inclined tunnel will again be used to charge a considerable length of rock, which will then be blasted out in a single operation.

Another aspect of the work which is not without interest is the grouting. The grouting tunnels at the lowest level are 600m long (see Table VII). Holes 180m long are drilled vertically from them, with the tunnels and drill holes higher up arranged to give complete coverage over a correspondingly wide area. Grouting is carried out from a central plant situated in a chamber excavated at the side of one of the road tunnels. There is a special tunnel for bringing in the cement from the ropeway terminal, and the various pumps and grout pans are all installed in this chamber, with lines leading off through the grouting tunnels to wherever work is in progress. There is an inclined railway for access leading down a shaft from the grout plant to the lower tunnels. When grouting is carried out, water is first injected into the holes under a pressure of twenty atmospheres. Then the cement grout is injected and the pressure is increased to a maximum of forty atmospheres.

TABLE VII—*Statistics of Mauvoisin Dam and Reservoir*

Dam

Maximum height above foundations, metres	237
Length at crest, metres	535
Width at crest, metres	14
Level of crest, metres above sea level	1961
Width of dam at base, metres	55
Total volume of concrete, cubic metres	2,100,000
Distance between radial joints, metres	18
Volume of excavation in loose material (scree and alluvial deposits), cubic metres	860,000
Volume of excavation in rock, cubic metres	420,000
Total area injected with cement grout, square metres	190,000
Length of four principal grouting tunnels, metres	1,000
Total distance drilled for grouting, metres	38,000

Reservoir

Top water level, metres above sea level	1,960
Minimum level, metres above sea level	1,800
Useful storage capacity, cubic metres	177×10^6 (about 143,500 acre feet)
Surface area of reservoir, hectares	205
Catchment area of River Dranse above dam site, square kilometres	114
Note.—The system of collecting aqueducts is co-ordinated with the Grande Dixence scheme as described in article No. I.	
Intermediate catchment supplying Fionnay intake, square kilometres	21
Extent of glaciers in catchment, per cent	41
Mean annual yield from catchment, cubic metres	250,000,000
Mean flow, cumecs	8

Water Control at Dam

Capacity of spillway, cumecs	100
Capacity of intermediate scour outlet at level of 1887, cumecs	125
Capacity of bottom scour outlet at level of 1792, cumecs	140

One of the items of constructional work at the dam site has not passed without some comment from those engaged on the work. We explained in the introduction to this series that negotiations for a hydro-electric project must first be carried out with the communes affected by it. One of the stipulations laid down in this case was that a track should be constructed, above the top water level of the reservoir, to allow access for men and cattle to the upland grazing areas above the reservoir site, and to replace the track submerged by the reservoir. This work has not proved easy along the steep sides of the valley, and the track has cost about half a million Swiss francs to construct. The work generally has, of course, also included the construction of site camps and access roads, as in the case with all of these remote mountain projects.

The geology of the Dranse valley is typically Alpine. The formations at the dam site are schistose, probably of Liassic age (Bündnerschiefer), several schists and allied rocks being present. The tunnel to Fionnay and thence to Riddes passes through the

Nappe du Grand Saint Bernard (a crystalline formation in which schistose rocks predominate), for the greater part of its length, but also through seams of Triassic rocks, such as quartzites, limestone and marble.

The following contractors were responsible for the main mechanical and electrical equipment of the Mauvoisin scheme :—

Fionnay Section.—One gate valve in scour pipe, Escher Wyss S.A.; two butterfly valves (2700mm diameter), Ateliers des Charmilles S.A.; pressure and surge shaft steel linings, Escher Wyss S.A., and Giovanola Brothers S.A.; three spherical valves (1250mm), L. de Roll S.A.; two Francis turbines, Escher Wyss S.A.; two three-phase alternators, 42·5MW, Brown, Boveri et Cie. S.A.; six single-phase transformers, Ateliers de Sécheron S.A.; travelling crane, 90 tonnes capacity, Ateliers de Constructions Mécaniques de Vevey S.A.

Riddes Section.—Four butterfly valves (1750mm diameter), at head of penstock, L. de Roll S.A.; two penstock pipes of 1·7m to 1·5m diameter, Sulzer Brothers S.A.; ten spherical valves (700mm diameter) and two 65-tonne travelling cranes, L. de Roll S.A.; ten Pelton turbines, Escher Wyss S.A., and Ateliers des Charmilles S.A.; five three-phase alternators, 45MW, and fifteen single-phase transformers, Brown, Boveri et Cie. S.A.

(*To be continued*)

E.R.A. Network Analyser

The Electrical Research Association, Leatherhead, is building an impedance network analyser having facilities for three classes of work, namely, the study of networks in the steady state at a single frequency, the study of networks in a transient state, and the study of the frequency response of networks. The analyser is being built in stages and the portion so far completed is described and illustrated here. It consists of three steady-state generator units, two wings of impedance racks, a connecting and indicating board and a control desk for steady-state studies. This represents roughly one-quarter of the projected equipment which will also include a separate control desk and measuring facilities for transient studies. The base values adopted are 100 *ohm impedance and* 1592 *c/s, with a frequency range from one-tenth to ten times the base frequency.*

RECENTLY we attended a demonstration of a network analyser which has been designed and built by the Electrical Research Association, Leatherhead. It is available for use in the solution of routine and research problems encountered by the electrical and other industries.

When the analyser was being planned it was realised that the network elements could in principle be used in three ways. The first was for the study of the behaviour of networks in the steady state at or near a single frequency, the purpose for which commercial analysers are specifically intended. The second was for the study of the behaviour of electrical networks in a transient state. Because of limitations of performance of the elements, commercial analysers are normally not suitable for this requirement, which is met by smaller, specialised equipments. The third purpose was for the study of the frequency response of networks. Facilities for this have, so far as is known, not hitherto been incorporated in conventional network analysers.

Because of the central position of the E.R.A., it was felt that facilities provided under any of these heads should supplement rather than duplicate those available elsewhere : that the equipment should preferably have greater range and higher accuracy, but that, although it should be more versatile, it need not be so well adapted for the rapid solution of classes of problem which can be solved on existing analysers.

Substantial economy seemed possible if all these requirements could be satisfied in a single set of elements and interconnections, used in conjunction with two kinds of generating and measuring equipment, for the steady state and transient state studies respectively. A survey showed that components incorporating techniques and materials now standard in the telecommunications industry could form network elements satisfactory for all purposes. Further, a considerable reduction of cost and bulk would be achieved if the operating power level and the frequency range of the analyser were within the range for audio-frequency telecommunication, since standard telecommunication components would then be satisfactory. This would necessarily call for rather sensitive and complicated measuring equipment, but it was estimated that there was an optimum level at which there was a considerable net gain. Also, only inexpensive components would have to be added should any future extension be required.

The frequency that may be covered by a set of network elements depends on the ratio of their impedances to the stray impedances of the interconnections, with a lower limit imposed by low-quality factor of inductors at low frequencies. The impedances of network elements cover a range centred on and expressed as percentage of a " base " impedance at a " base " frequency. A high base impedance gives preponderance to shunt strays, while with a low base series impedances of leads become more dangerous. In the case of the E.R.A. analyser, by adopting base values of 100Ω and 1592 c/s ($\omega = 10^4$), and by using components of small dimensions it was possible to obtain a useful frequency range of 100 : 1, extending from one-tenth to ten times the base frequency. Studies can, of course, be made over a wider frequency range by using the expedient of frequency modelling.

Accordingly the following base parameters were chosen for the analyser.

Impedance 100Ω (10mH and 1 μF).
Power 2·5mW (500mV and 5mA).
Frequency 1·592 kc/s ($\omega = 10^4$ rad/sec.)
Frequency range 0·159 to 15·9 kc/s.

It was decided that the resolution and repeatability of the measuring equipment should preferably be as high as 0·1 per cent of base amplitude and 0·1 deg. of angle for amplitudes greater than 10 per cent.

The impedance and power level chosen resulted in a signal of 100μV for the metering of a current at 100 per cent level. The desired amplitude resolution called therefore for a sensitivity of 0·1μV in the current measuring equipment, while the phase resolution required sensitivity of 0·016μV.

Progress in the Design and Construction of the Analyser

The project was one of considerable size and difficulty, requiring a number of years for development and construction. The design was therefore so arranged as to permit progressive commissioning into service of each completed part of the equipment. The complete equipment will comprise eight wings of racks housing the network elements which will be connected to four interconnecting units or plugboards with the central measuring equipments for the steady state and transient studies respectively in two control desks placed at the opposite ends of the array. All the network elements will be available for use in conjunction with either control desk on problems of exceptional magnitude. Normally, however, the wings of racks and the plugboards will be suitably apportioned between the two desks, so that studies may be carried out simultaneously on two independent networks, this giving a high utilisation factor for the equipment.

A single wing of racks (left, Fig. 1) and a small plugboard was first constructed in 1951, and in conjunction with commercial transient generating and measuring equipment has been used for the solution of transient state problems. This has now been supplemented by a second wing of racks (right, Figs. 1 and 2), a full-size plugboard, three steady-state generators, and the steady-state control desk with the full equipment required for use with the complete analyser, as shown in Figs. 1 and 2. The absolute accuracy of the main metering system is within ±1 per cent at the base frequency and the targets of resolution and repeatability have been achieved. Measurements can be made over the whole frequency range of the analyser ; at present the accuracy falls off considerably near the extremes of the range, but, as indicated later, it can be improved by a relatively simple modification.

Passive Network Elements

The " passive " network elements consist of two terminal elements, such as decade impedances or simple series or parallel arrangements of these, and three or four-terminal elements such as

Fig. 1—E.R.A. Network Analyser. The Network Elements, Indicating and Plug Board and the Slave Generators can be seen in the Background. The Control Desk for Steady State Studies is in the Foreground. The Master Oscillator and Main Metering Panels are on the Operator's Right

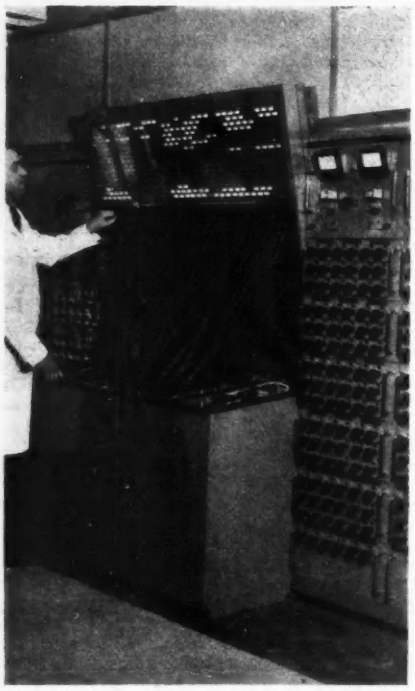


Fig. 2—The Indicating Board and, on the Right, Racks Containing Slave Generators at the Top and Rack-Mounted Network Elements Below

π networks and transformers, together with some electronic amplifiers. The terminals of each two-terminal element are brought out and identified by colour (red or black) at the ends of flexible conductors at the plugboard. Three or four-terminal units are treated as pairs of two-terminal units. Each unit has also four terminals available for the purpose of metering, i.e. two voltage terminals and two current terminals. The latter are the potential terminals of a 20mΩ shunt incorporated in the red lead of each unit.

The constituents and the impedance range of the various types of units are given in detail in Table I, together with the number of units provided for and the number already available. The most important properties of these units are accuracy and compactness. The accuracy is, in general, within 1 per cent of the nominal setting or 0·1 per cent of the base value, so that for most problems the dial readings can be used without any corrections. The purity of the reactive components is also better than 1 per cent at the base frequency. The types of components used are listed in Table II. The size of the components is so small that for all but the high susceptance units the space taken up in the racks is determined by the front panel requirements for the indicating dials. Small and inexpensive wafer-type switches with silver alloy contacts used both in the network units and in the selector system have proved completely satisfactory.

Table I—*Details of Network Elements*

Type of unit	Resistance R%		Reactance X%		Susceptance B%		Connections	Number available	
	Max.	Steps	Max.	Steps	Max.	Steps		Final	Present
High impedance (load)	10,100	10	1,900	5	—	—	Series & parallel	60	33
Medium impedance (load)	1,110	1	1,900	5	—	—	Series & parallel	42	—
Low impedance (line)	110	½	110	½	—	—	Series	126	36
Low susceptance	—	—	—	—	109	½	—	72	30
High susceptance	—	—	—	—	1,000	100	—	48	12
π Network	110	½	110	½	2×109	½	π	48	—
Steady state generators			E=0—400%					18	3
Auto-transformers, coarse (system transformers)			100%±30% in steps of 0·5%					18	8
Auto-transformers, fine (load adjustors)			100%±10% in steps of 0·2%					64	2
Mutual transformers			Ratio 1 : 1					12	2
Mutual transformers			Ratio 2 : 1 or $\sqrt{3}$: 1					8	—
Amplifiers and buffers			Gain 10 : 1 or 1 : 1					12	4

NOTE.—48 auto-transformers, 24 high impedance units and 24 medium impedance units will be combined into 48 load units provided with individual voltmeters.
Generators and auto-transformer units will incorporate two-decade reactances.

ACTIVE NETWORK ELEMENTS ("GENERATORS")

Three generators of a conventional design have so far been constructed to act as steady-state power sources. One of these generators is housed in the top of each of the three panels which can be seen to the right of the plugboard in Fig. 1 (see also Fig. 2). These "generators" are in fact adjustable amplifiers, with an independent phase and amplitude control in each unit, as shown in Fig. 3. The output amplifier ensures a low output impedance of 0·3Ω. Provision has been made for the insertion of built-in adjustable reactances and power and terminal voltage monitors, which will result in a considerable economy of time required to achieve the initial balance in load flow studies. It is expected that the additional generators to be constructed will incorporate results of research now in progress at several centres, aimed at producing self-adjusting units embodying all the important characteristics of the actual machines.

CENTRAL MEASURING EQUIPMENT FOR STEADY-STATE STUDIES

A block diagram of the analyser shown in Fig. 4 indicates the relations between the various constituents. The main measuring system consists of three automatic alternating current potentiometers operating simultaneously to indicate the potential difference V (amplitude and phase) between the selected points in the network, the current I through the selected unit (amplitude and phase), the direct phase difference ϕ between V and I and the products $VI\cos\phi$ and $VI\sin\phi$. These two products give the active and reactive load (watts P and vars Q) when V and I refer to voltage across and current through a unit or network. An independent direct voltmeter is also provided mainly for the purpose of quick checks and for monitoring a voltage across one unit while adjustments may be made to other units.

The reference signal for the bridge measurement is derived from the same three-phase master oscillator which provides excitation for the generator units. Details of the three bridges are shown in Fig. 5. It will be seen that the measurement of voltage (or current) is made by comparing the selected voltage signal from the network nodes (or from a shunt) with a reference signal derived from a potentiometer. The difference of these two voltages operates a servo-system which adjusts the slider position on the potentiometer and the phase of the signal supplied to the potentiometer until a balance is obtained.

The angular positions of the shafts of the potentiometers and phase shifters are coupled to dials on the control desk which display current and voltage in amplitude and in phase relative to a reference signal, together with the phase angle between them. The main metering dials can be seen in the centre of the control desk, just to the right of the operator's hand in Fig. 1. The measurement of active and reactive load, which is usually difficult in variable frequency systems, has been made fairly easy by the use of an analogue method. The multiplying operations required are performed on a fixed frequency analogue signal by means of potentiometers and a sine-cosine resolver ganged with the voltage and current bridges. The accuracy of these operations is governed by the linearity of the potentiometers (which is 0·1 per cent) and linearity of the sine-cosine resolver. The latter at present introduces errors of up to 2 per cent at low power levels, but these errors will be eliminated by a rearrangement of the circuit permitting the operation of the resolver at a fixed voltage level.

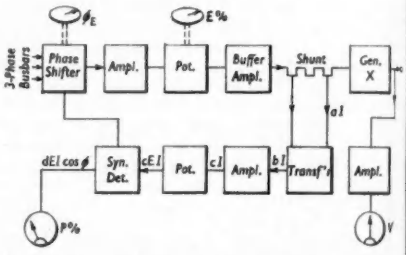


Fig. 3—Block Diagram of Steady State Generators

The bridge method of measurement is necessarily somewhat slower in giving an indication

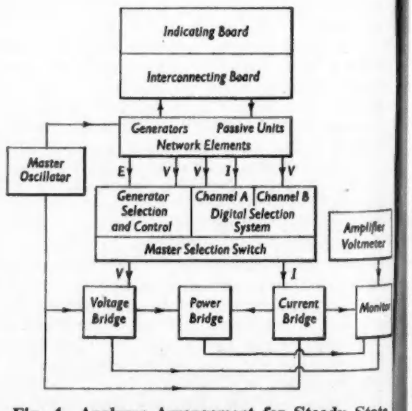


Fig. 4—Analyser Arrangement for Steady State Studies

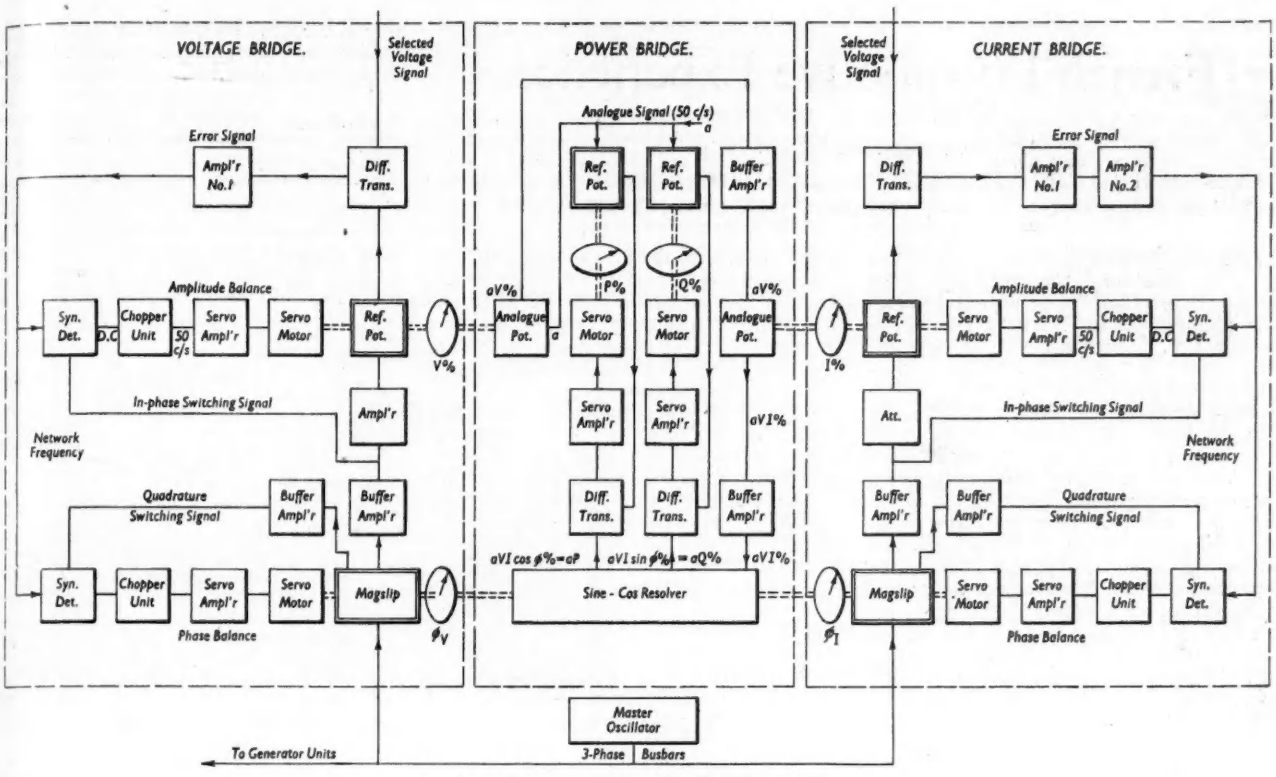


Fig. 5—Block Diagram of Bridge Measuring System

than is a direct measurement. This is compensated by the greatly increased scale length (20in), which reduces the time and effort of the operator in taking a reading.

The direct measurement of voltage is made by means of an amplifier-operated rectifier instrument. Amplitude only is measured, but phase angle may be indicated on one of the monitoring cathode ray tubes. Three such tubes are provided for permanent display of voltage waveforms at important points in the measuring system which can be selected at will, thus facilitating adjustment and giving immediate indication of faults. These three tubes can be seen at the top of the left-hand panel on the control desk (Fig. 1). The master oscillator and the electronic components of the main metering system are housed in a panel to the right of the control desk (Fig. 1).

Remote Control and Selection System

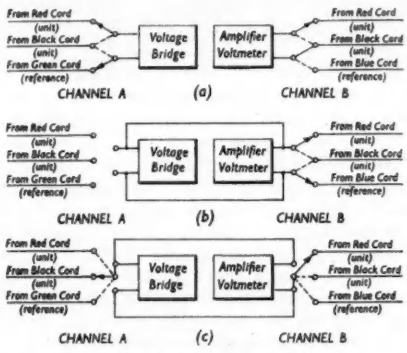
Each impedance unit is assigned a three-digit number. The first digit denotes the wing of racks in which a unit is situated, and the plugboard at which its terminals are available, the second and third denote the type of unit and its serial number. Selector gates, i.e. banks of relays housed behind the plugboards, are operated by push-button controls at the control desk and connect the measuring equipment to the metering terminals of a unit. The selector push buttons are arranged in two groups flanking the main metering dial on the control desk (Fig. 1).

There are two independent channels of selection, *A* and *B*. Channel *A* has both voltage and current leads and normally connects to the bridge equipment, channel *B* has voltage leads only and normally connects to the amplifier voltmeter. In addition, each channel has its own potential lead (green and blue for channels *A* and *B* respectively), which may be plugged in anywhere in the network, but will usually be connected to the neutral bar. Thus three voltage terminals are available in each channel, and several modes of measurement are possible through the use of a master selection switch, as shown in Fig. 6. By the use of the two channels with the bridge equipment voltage and current may be measured in different units simultaneously, so that mutual effects in a network may easily be studied or the product of two unrelated synchronous complex quantities obtained.

It was estimated that the generators would most often be selected. An additional single-digit selector channel has therefore been provided to make them more readily available. The phase and magnitude of a generator thus selected may be adjusted from the control desk. It is also possible to make such an adjustment while some other unit is selected for measurement through channels *A* or *B*.

Conclusion

The part of the analyser now constructed is fully representative of the complete equipment. Its present performance is very encouraging, as we



Alternative switch positions shown dotted

Fig. 6—Alternative Modes of Voltage Measurement

were able to judge during the recent demonstration of the analyser at the E.R.A. Laboratories, 5, Wadsworth Road, Perivale, Greenford, Middlesex. There tests were carried out to show that the resolution and repeatability of the measuring system was within the values specified. It was also shown that the specified accuracy was maintained over a 4 : 1 frequency range.

We learn that the frequency dependent error is mainly due to the fact that for certain of the bridge elements air-cored components were used initially, whereas powder-cores were used in later versions. By standardising on powder cores throughout this error will be greatly reduced. The analyser is now available for the solution of problems within its range. In addition to the normal power system problems, the more obvious uses are for studies in transient response of networks, frequency response of networks, and, because of inclusion of isolating elements, i.e. amplifiers, the analysis of feedback amplifiers and servo-systems.

Techniques for the latter fields, and specialised auxiliaries for the most efficient applications, naturally require development and it is expected that this will be pursued in parallel with the use of the existing equipment and construction of its complement.

The central measuring equipment may be used as a very sensitive and versatile alternating current potentiometer, independent of the network.

It is expected that the complete equipment will be first available in the new E.R.A. Laboratories at Leatherhead : in the interim period extension to one-half, and possibly three-quarters of the ultimate size will be carried out at Perivale, where the equipment has been, and will continue to be, available for general use.

Five classes of work are envisaged in the following order of priority :—

(*a*) Work within the general framework of E.R.A. programmes.

(*b*) Work for individual members which is essentially of a research character.

(*c*) Solution for members of problems which are not of a research character.

(*d*) Work for other central organisations.

(*e*) Work for non-members.

Light-Alloy Storage Drums.—We have received details of new 45- and 40-gallon corrosion-resistant storage drums which are now being produced by E. C. Payter and Co., Ltd., Meeting Street, Great Bridge, Tipton, Staffs. These drums are fabricated from sheets of 14 or 16-gauge magnesium-aluminium alloy, and automatically welded, without flux, using an inert gas-shrouded arc. For each capacity a heavy-duty standard or export version is available with any aperture or bung arrangements required.

Spheroidal Graphite Iron Castings.—The formation is announced of the British S.G. Iron Producers' Association from amongst the licensees in Great Britain and Northern Ireland of the process under British Patent No. 630,070 and others for producing spheroidal graphite iron castings. The Association has been brought into being to facilitate the exchange of information on the manufacture of this material, and to encourage its use in the many applications for which it is suitable. It is also co-operating with the British Standards Institution in the preparation of a specification. Mr. P. A. Russell and Mr. W. R. Cooper have been elected chairman and vice-chairman respectively of the Association, and Mr. C. Gresty has been appointed honorary treasurer. The secretariat and offices are at 94–98, Petty France, London, S.W.1.

French Locomotive Experiences

By EDWARD H. LIVESAY

(*Continued from page 596, April 23rd*)

No. VIII—PARIS/AULNOYE, THREE-CYLINDER SIMPLE "HUDSON" No. 232.R.001; LILLE/PARIS, FOUR-CYLINDER COMPOUND NO. 231-E42

THE introduction to Article II of this series mentioned that there are three classes of "Hudson" type express locomotives running over the Northern Division of the S.N.C.F., designated "R," "S," and "U," the "S" and "U" being four-cylinder compound and the "R" three-cylinder simple; the present article deals with the latter. The general design of all three classes is very much the same, apart from necessary variations resulting from the utilisation of simple and compound expansion and three and four cylinders respectively. The chief detail differences between the two classes, simple and compound, concern the arrangement of the cylinders and their associated mechanism, the drive of the compounds being divided between the first and second coupled axles, whereas all three connecting-rods of the simple engines drive the second axle. This brings all the cylinders side by side in the "R" class, though the middle cylinder has a somewhat steeper inclination than the outside pair, in order that its connecting-rod may clear the leading coupled axle. This juxtaposition of the cylinders enables the cross shaft of the "Dabeg" valve gear to be common to all three sets, running right through from side to side, without the necessity for additional mechanism to actuate the centre valves, which would be required if the drive were divided and the middle cylinder placed far forward. The piston-rod of the middle cylinder is lengthened, and the connecting-rod also is necessarily longer than in the case of the four-cylinder compounds with their advanced high-pressure cylinders. Apart from these and certain other minor details, such as the fitting of a "Lemaitré" blast pipe instead of a double-blast "Kylchap," as used on "U1," there is little difference in the general layout between the latter and the "R" class engines with which this article deals, though it should not be overlooked that "U1" employs Walschaerts gear and piston valves, as against Cossart gear and "Dabeg" poppet valves. Fig. 43 shows "R1" as originally run with streamlining, but this has been removed for the usual reasons—it is of little advantage except at very high speeds, which are not permitted on the S.N.C.F., and it is a fitter's nightmare. Fig. 44, a picture taken at Aulnoye on the occasion of the run described in this article, shows the engine in its present condition.

Some of the chief dimensions are tabulated in the next column.

The "Dabeg" (improved Lentz) valve gear fitted to the "R" class of locomotives is used extensively on the S.N.C.F. and is similar to the system developed by the Associated Locomotive Equipment Company in England, and fitted to various types of engine during recent years. It can be either of the oscillating or rotary cam pattern; when the former it is actuated by Walschaerts gear in the usual way, but in the latter case it is worked either by bevel gears and rotating shafts or by the Cossart arrangement of rods; the latter will be seen in Fig. 43. The Cossart valve gear was first fitted to the big 2–8–2 tank engines, which were described in Article VI, covering the operation of local "pull-and-push" trains. With this gear ("Dabeg") the camshaft extends right across the engine and actuates four double-beat valves arranged in pairs at the ends of each cylinder by means of a series of stepped cams, which move the valves through intervening fingers, provided to relieve the tappets of non-axial thrust. The cams are so contoured that lead is progressively increased as the cut-off is shortened, beginning from zero in full gear. The camshaft is splined, the cams moving transversely to bring about cut-off variation and reversing.

The drive is taken from return cranks on the main outside crank pins, set at 180 deg. from the latter and at 120 deg. from each other, thus bringing about continuous rotation of the camshaft. As will be seen in Fig. 43, the rods between the return cranks and the lower end of the rocking levers are heavily weighted at the forward ends; this mass is provided to balance the reciprocating masses—piston, piston-rod, crosshead, &c.—which can be done in this way as the valve rods move in opposition to the former, the return cranks being at 180 deg. to the main cranks. The balance weights in the wheel rims, therefore, only concern the revolving masses.

Cylinders (three)	21·6in by 28in
"Dabeg" rotary cam poppet valves, Cossart drive	
Valves:	
Admission diameter	8·8in
Exhaust diameter	9·6in
Lift	1in
Admission, maximum	95 per cent
Minimum	13·6 per cent
Inclination of cylinders	Outside 5 per cent, inside 10 per cent
Heating surface:	
Firebox	272 square feet
Tubes and flues	1853 square feet
Schmidt superheater	697 square feet
Total	2822 square feet
Grate area	56·4 square feet
Boiler:	
Diameter, minimum	70in
Length	16ft 2in between tube plates
Height to centre line	10ft 4in
Pressure (20 hpz)	294 lb per square inch
Wheels:	
Diameter, bogie	3ft 3in
Driving	6ft 8in
Trailing truck	3ft 3in
Weight on bogie	28·4 tons
Weight on driving	69·0 tons
Weight, trailing truck	26·8 tons
Total	124·2 tons
Speed limited to	88 m.p.h.
Tractive effort at 85 per cent	57,341 lb

Equipment: "Lemaitré" variable blast pipe; mechanical stoker, H.T.1 type; Hudson grate; four Martin mechanical lubricators and Tecalemit grease system at various points; Westinghouse compound pump; roller bearings on both trucks; Dalmar tube cleaner.

It will be noticed that the heating surface, 2822 square feet, of these "R" class engines is somewhat smaller than might be expected when associated with three cylinders, 21·6in by 28in, but offsetting this, the grate area, 56·4 square feet, is large, and the firebox volume, plus that of the combustion chamber, is also large. As 1 square foot of heating surface in the firebox is worth two or three elsewhere, the moderate tube length, 16ft 2in, is all that is necessary. The degree of superheat, too, is high, as is the pressure, 294 lb, and as the A.C.F.I. feed water system is, as usual, provided, there is no doubt that the boiler power is more than adequate. The boiler being of large diameter and high pitched, notwithstanding the generous French loading gauge, there is no room for a dome, a slotted dry pipe being provided in its place.

Other interesting details are the provision of clasp brakes for the driving wheels, the block pressure varying automatically according to the engine speed; it is air braked, not steam. Water can be projected into the ash pan; complete electric lighting is, of course, fitted; the firebox is of steel and contains four arch tubes.

The run described in the present article did not happen to involve very heavy work, the train load being comparatively light, but

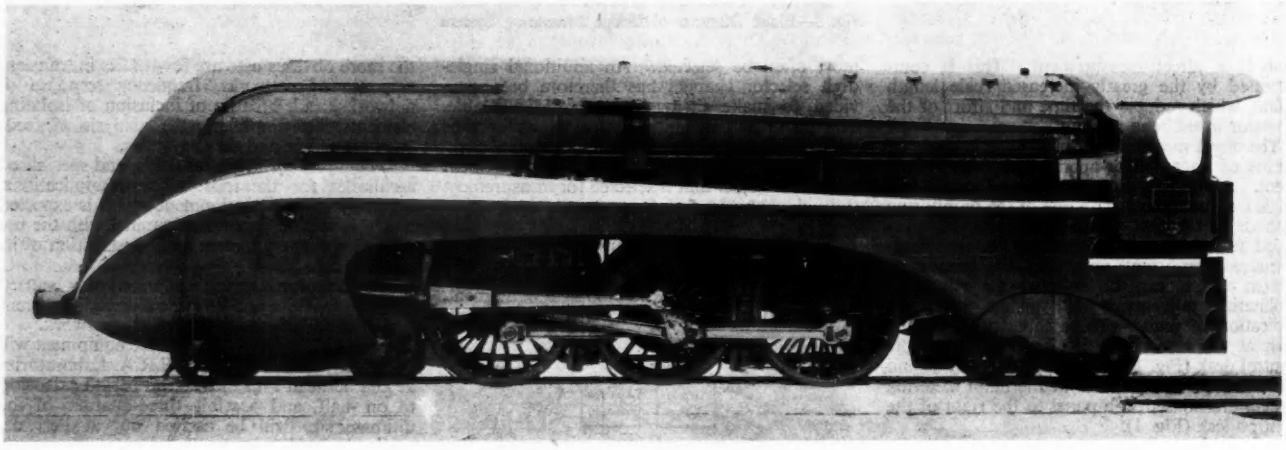


Fig. 43—Three-Cylinder Simple 4-6-4 Express Locomotive No. 232.R.001

these " R " class engines—in fact, all the three " Hudson " classes—have done remarkable performances, such as taking loads of 650/700 tons up the long 1 in 200 climb to the Survilliers summit at over 60 m.p.h., and Creil, 30 miles, reached in 30 min. The actual work done by the " S " compounds and the " R " simples has been very much the same, but the simples have naturally been found heavier on fuel and water. Judging from the trips made by the writer on " R1 " and " U1," the respective riding of these locomotives leaves nothing to be desired

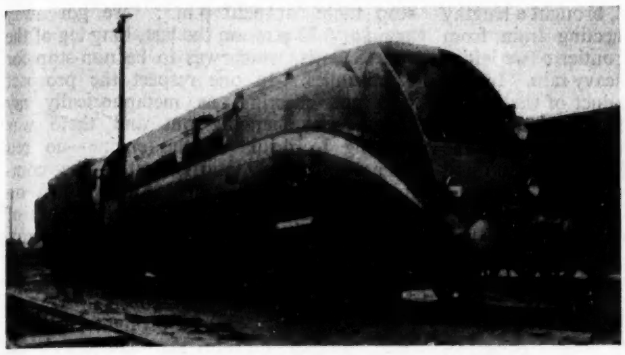


Fig. 44—Locomotive No. 232.R.001 at Aulnoye

and there is nothing to choose between them.

The engine on which the run was made, No. 232.R.001 (Fig. 44), was taking the 8·03 a.m. train from the Gare du Nord to Lille, via Aulnoye and Valenciennes, a different route from the more direct one through Longueau, Arras and Douai. While waiting for the engine, I boarded the four-cylinder " Hudson " of the same general design that was at the head of the 8 a.m. Lille train on the other side of the platform, to look at an oscillation meter that was being set up in the middle of the cab floor. I rather wondered why observations were being made of oscillation on these fine-riding " Hudsons " —so far as my experience of " U1 " went, there was no oscillation worth observing ! But French engineers are very thorough, and evidently difficult to please. Our train pulled out promptly at 8.03, with Monsieur Hugot driving, my friend Fillon and the regular Mecanicien Gauthier standing by ; I seem to have overlooked the chauffeur's name. The load was 580 tons gross, a mere bagatelle to such an engine as this—Fillon described it as " So-so ! "—and as the grade out of the Gare du Nord is a descending one to St. Denis, the get-away was snappy on the dry rails, the weather being fine though dull, after a thunderstorm in the night. Despite the fact that " R1 " had run 90,000 miles since last shopping, and was due for " hoisting," her riding was very good—this is underlined in my notes, so it *was* good. After riding so many four-cylinder compound machines it was quite strange to hear the more rapid, staccato beat of this triple-cylindered h.p. engine ; it sounded more British than French, and, of course, at a very moderate rate of travel the beats merged into one continuous note, less harsh than the average British sound, due to the engine being fitted with a five-jet Lemaitre blast pipe. The stoking was mechanical, as on all these " Hudsons," and the coal screened, small and clean.

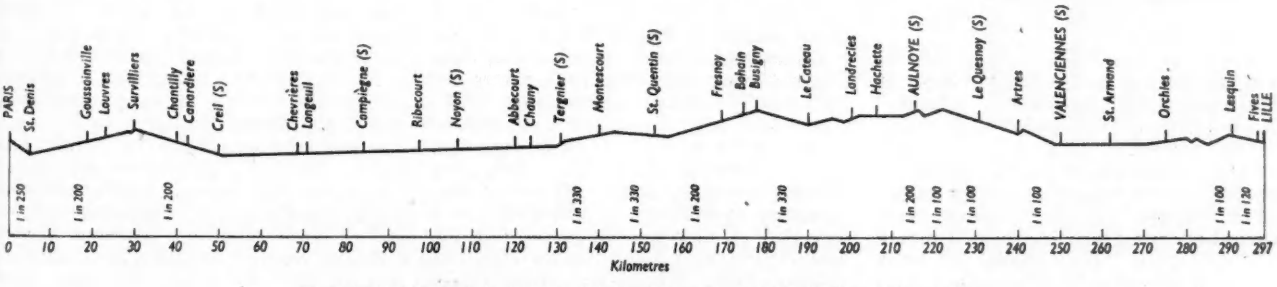
Watching the 8 a.m. train leave the Gare du Nord, I had inquired as to the well-being of my beloved " U1," and was disturbed to hear from Fillon that it was "off" this day, the middle big-ends needing a little attention. I asked if middle big-ends were the Achilles heel of these wonderful compounds, as they are apt to be on three-cylinder engines in Britain, but was reassured; the attention being given " U1 " was of merely routine nature, and did not indicate a weak spot in the design. Nevertheless, it may be mentioned *en passant* that if a further series of express engines were to be built by the S.N.C.F. they would be three, rather than four, cylinder machines.

" R1 " was steaming very well, and blew off while running fast up the long Survilliers bank, which begins at St. Denis (Fig. 45), and was taken at any easy 60 m.p.h. Nobody would have guessed the engine was due for shopping ; it was not only riding beautifully, but there was not a knock nor sound from any of the motion or running gear ; things could not well have been better. They must have the right kind of men in the shops at La Chapelle, where these " Hudsons " are shedded. They have a central sand blast tube cleaning device, much the same as is found on the Stanier " Pacifics " and other ex-L.M.S.R. engines. On the Survilliers climb the regulator was full open, and the cut-off roughly 10 per cent, with the pressure right up ; on the descent down the northern side to Creil the speed was 70 m.p.h. or so ; it is limited to about 75 m.p.h. for track reasons—I have it as both 73 m.p.h. and 78 m.p.h. in my notes at different places, so will strike an average !—and as I find a reference to the 23-ton axle load in my log, which is above the usual on French locomotives, it may be Fillon had said the speed was limited for that reason. Which reminds me: chatting with a Cook's man at the Gare du Nord, and these " Hudsons " coming into the conversation, he has said that when one of them had been running trials, it had torn the track to pieces. The reader should do what I did—take the information with a grain or two of salt ! This is just the sort of story which gets circulated by the uninformed ; it may have some faint grounds for credence, but gets exaggerated and distorted out of all semblance of truth, and can generally be heavily marked down.

Creil, 8.39 a.m., 30 miles in 36 min, slightly late, due to the slow over the Canardiere viaduct, and coming to a stand in the station ; leaving at 8.41 a.m. we swung off to the right on the line to Aulnoye, the track picking up the Oise River, alongside which it ran for several miles. It came on to rain steadily, and the outlook became somewhat drab, but the cab, with its roof carried well back, gave adequate protection. I noticed that the deflector inside the firedoor was fixed, dividing the fuel into two showers, one to each side of the box ; in N. America it can be hand-controlled, but this was evidently not considered necessary for a 56 square feet grate. Compiégne brought the next stop, 8.58 a.m., O.T., 52 miles in 55 min, 57 m.p.h., inclusive of the 2 min stop at Creil ; the late arrival at Creil had already been cancelled out. It seems that in France the making up of lost time is regarded as a first essential, the driver getting a bonus for so doing. It was raining steadily, but one could only feel glad at this, after the long drought, and the parched soil was drinking thirstily of the God-given moisture. Noyon, and another stop, 9.18 a.m. ; this was a secondary train, but the halts gave the engine all the more to do in keeping a fairly high overall average ; there was never any slipping at the get-aways, despite the wet rails. It was noticed, too, that there was hardly any relative motion between engine and tender, the riding of both at 75 m.p.h. being so perfect that my notes look as though they were written on *terra firma*—they are as good an oscillation meter as that I saw installed on the " Hudson " at the Gare du Nord. My notes of the running of the " Americaine " 2–8–2, now, are often only readable from the context, or when instinct tells me what they must mean.

Tergnier, the fourth stop, was made at 9.31 a.m., O.T., after an approach up 1 mile of 1 in 200 ; there is a big marshalling yard here, with a roundhouse and coaling stage. Away again at 9.33 a.m.—stops in France at other than important places are seldom more than for 2 min—with 13 miles to the next one, St. Quentin, and only 15 min to do them in ; actually the distance was covered in 12 min, or at well over 60 m.p.h., as we arrived at 9.45 a.m., 1 min early. As 8 of the 13 miles are on up gradients varying from 1 in 125 to 1 in 200, the thing looks a little far-fetched—with 580 tons—but I am prepared to say the figures are correct enough ; " R1 " was an exceptional engine !

From Creil to Tergnier, 49 miles, it had



The profile from Lille to Paris, via Arras, will be found in article No. II—Part II, March 12th, page 378.

Fig. 45—Profile Paris/Lille, via Aulnoye

been mostly a steady rise, but from St. Quentin, left at 9.48 a.m., a stiffer climb still began, extending nearly to Busigny, the next stop being at Aulnoye. Many of the stations were nostalgic of the first war, but they were only names to me, an ex-Naval man ; I noticed nothing in the way of damage arising from the last war.

These three-cylinder engines, I was told, burn 20 lb more coal per mile and evaporate considerably more water than four-cylinder compounds of similar power ; the former figure becomes about 75 lb per mile with a 600-ton train but, being more costly to build and maintain, the four-cylinder type is definitely " out " so far as the S.N.C.F. is concerned. So also is the three-cylinder simple design ; should any more express engines be built they would be three-cylinder compounds, Smith system, but unfortunately it is improbable any more steam locomotives will be called for—electricity is the motive power of the future. " R1 " had done 7000 miles per month regularly ever since it was built, its daily run being generally to Lille, or the Belgian border, and back to Paris, though for some reason I seem to have omitted to note, on this particular day it was only going as far as Aulnoye.

Fillon, as usual concerned about my well-being, inquired whether I was " content " ; I assured him I was quite happy—even the rain did not depress me. How could I help being happy, with this splendid machine spinning along at 75 m.p.h. in its inimitable manner, even after having done 90,000 miles since " hoisting " ? The suspension was evidently very good indeed, particularly the trailing truck ; the engine felt as though it had springs in its heels—as, of course, it had !—its action was buoyant, easy, a pleasure to sense. The " feel " of all these French engines was different from that of any others I can call to mind—it is quite individual.

At Hachette a signal check brought us down to 25 m.p.h., and a few minutes later we came to a stand at Aulnoye, 10.35 a.m., O.T. The train had covered 134 miles in 152 min gross, 141 min net, with five stops and two checks, limited throughout to 75 m.p.h., which makes the running average 57 m.p.h., without any allowance for slowing and restarting. A very good and typical performance over a quite heavy route, the greater part of which had been on up gradients.

At Aulnoye No. 232.R.001 came off the train, proceeding to the shed ; here we transferred to a 1923 Chapelon " Pacific," No. 231-C40, a hand-fired " chain-gang " engine, i.e. one allocated to any and all duties, having no regular runs or crew. The enginemen's own engine was under repair, and they begged Fillon to tell me they were ashamed of such a dirty machine. I replied " C'est n'importe!" dirty engines not being altogether unknown in England ; I have travelled on several there in a state of unspeakable filthiness.

The train load was 530 tons gross, and it left Aulnoye at 11.45 a.m. on the 49-mile run to Lille. The rails were wet ; yet, as usual, no slipping took place. It is easy going to Lille, being very steeply down to Valenciennes, and mostly level from thence to the finish. The first stop was at Le Quesnoy, 12 noon ; at the restart, this being a compound, h.p. steam was used in all the cylinders, controlled by the usual auxiliary regulator. The front windows were of the Potier type, in which external wind deflectors take the place of glass, and are supposed to be equally effective. It is an ingenious arrangement which I remember admiring when it was introduced some years ago, and I asked Fillon whether theory and practice agreed. His reply was a shrug of the shoulders and again the verdict " So-so ! " This needs no amplification.

Both enginemen looked very young, and were 28 and 25 respectively. The *mecanicien* was an exceptionally smart fellow, slated for foreman, and both had what Fillon described as *sympathetique* faces—bright, intelligent and so forth. I agreed, but added that in my experience most French enginemen had the same appearance, and by their treatment of me had shown that it did not belie them. But there—in this world one generally gets what one gives—their sympathy only reflected mine !

Valenciennes, 12.17 p.m., brought a lengthy stop, waiting for a connecting train from Feignies, on the Belgian frontier ; we left at 12.28 p.m., 5 min late, in heavy rain. Lace is evidently not the only product of the Valenciennes district ; slag piles dotted the landscape, and the country was very level in the direction of Lille and Lens. Bearing in mind the age of the engine, and its chain-gang reputation, its behaviour was quite respectable, though naturally not up to what I had come to regard as the French standard. The track, too, was not in the best of shape, as I had noticed between Aulnoye and Valenciennes ; after this, it began to improve, but neglecting the " touch wood " principle, I had scarcely entered the fact in my notebook when it suddenly became much worse. Orchies brought a sombre aspect to the somewhat dreary outlook ; I was told that here the Nazis had massacred the whole population in the way the world wots of. Shortly after, the train ran into Lille's dead-end station, coming to a stand at 1.05 p.m.—of course, on time—49 miles in 80 min, inclusive of two stops totalling 13 min, 44 m.p.h. This too, was not an important train, and had merely been taken to get me to Lille from Aulnoye without any delay.

At Lille there was the customary pleasant lunch with the Superintendent, Monsieur Courtin, Messieurs Hugot and Fillon, in the same fine restaurant where, on my first visit, I had been so embarrassed by being " out of the rig of the day." On this occasion I had brought appropriate habiliments with me, having learned my lesson ; overalls are *de rigeur* in the cab, but they are out of place at a luncheon table. Justice having been done thereat, we proceeded to the yard, picking up engine No. 231-E42 for the return trip to Paris, a 4–6–2 four-cylinder Chapelon compound dated 1937, a very fine machine. The load was nothing, so to speak ; a mere 500 tons gross, which was not likely to cause such a powerful machine any concern. We left Lille at 4.35 p.m., in fine, cool weather, with Monsieur Hugot at the regulator, and Fillon in attendance ; I was glad of this, something—possibly the lunch—giving me the idea that his invaluable assistance might become more than usually apropos. My notes show that for some reason or other I was rather less observant than as of yore ; I have not got the crew's names, for instance, nor details of the engine, which, however, were probably much the same as the " Golden Arrow " Chapelon, No. 231-E16. For this omission I tender apologies. Something seems to have been amiss ; French hospitality, so generous, so charming, is at times apt to overwhelm a visitor from the land of austerity ; in a word, he should watch his step.

The heavy climb out of Lille, beginning almost immediately clear of the platform, was taken fast ; over the top, the speed rose rapidly on the easy going to Douai, nearing the track limitation of 75 m.p.h. The Douai stop was made at 4.59 p.m. ; 21 miles in 24 min, and we left at 5.01 p.m. ; no time is wasted at stations. The riding of the engine was very good indeed ; it was a 1937 machine, and all the motion and running gear was in impeccable condition. Following Douai the speed again reached the liberal 70s ; the grate was rocked and the coal noted as being better than average ; the junction for Lens passed and the rain ceased, as we hoped for good. It was heavy climbing here, through Arras, and continued so to the Achiet summit, but this had no effect whatever on the steaming, No. 231-E42 blowing-off vigorously approaching Arras, and again on coming to a stop there, at 5.20 p.m. ; we got away again at 5.23 p.m. on the last, long leg of the run to Paris, which was to be non-stop for 115.5 miles. In one respect the prospect was not cheering, as metaphorically my tongue was hanging out and there was nothing to drink on the engine—no red wine, not even liquorice-water—the commissariat department had fallen down on the job. My hint that there was plenty of water in the tank was received with horror, notwithstanding assurance that I had many times drunk stinking water out of sloughs on the prairie without ill-effects—"n'est ce pas possible ! " So the drought that had been broken outside the cab continued inside—I was going to wilt badly before reaching Paris. Why, oh why, had I let myself go so at lunch ?

The silence and sweetness with which this complicated four-cylinder machine worked were very impressive ; there was not a sound from anything save the exhaust ; not a knock, pound or leak anywhere. I was told the exhaust-pressure when the engine was working hard on an up gradient would be about 3 lb to 4 lb, but this could not be verified as the exhaust gauge happened to be missing. The engine was fitted with the " Kylchap " double blast pipe with adjustable nozzles, as many, though not all, of these big machines are. On the down grade beyond the Achiet peak the speed was 77 m.p.h. ; the limit, it will be remembered, was 78 m.p.h. for track reasons. Passing through Albert, still descending, the respective h.p. and l.p. steam chest pressures were 14 lb and 3 lb, respectively ; probably there had been a slowing for Albert before the engine picked up again. A three-car " Autorail " passed ; these were said to be very fast, making the Paris/Lille run in 25 min less time than our train.* Between Longueau and Creil a sharp track-laying restriction reduced the speed to 20 m.p.h. and here the rain came on harder than ever ; climatically the run was a wash-out, but for no other reason. Unfortunately the drought inside the cab continued and was getting quite serious ; everyone seemed suffering from it. The speed remained near or over 75 m.p.h. for many miles coming down the southern side of the Gannes bank through Clermont to Creil, where the ritual slowing through the big junction checked it ; it was followed by another over the Canardiere viaduct beyond. This has come into several of these articles, reference having been made to the speed reduction always called for when crossing this war damaged structure. Reconstruction has, of course, since been carried out but to what extent I cannot say, having only made the briefest acquaintance with it on several occasions when running over it. It is probably not yet completely rebuilt in permanent shape, as a restriction is still in effect when crossing. Here the rain finally ceased, when the run was nearly over ; only 31 miles to

* Covered in Article No. III, Part I

Paris, with less than half-an-hour to cover them in, and we were 2 min late. There were no seats on this engine and I had been standing all the way from Lille, but perhaps this was fortunate, as if I had sat down I should only have fallen asleep at once, and should have lost my reputation for toughness, which was becoming legendary.

The long pull up through the Forest of Chantilly was taken in splendid fashion, seemingly at scarcely reduced speed, about 70 m.p.h. ; this was becoming familiar ground to me and was cheering ; it showed we were nearing Paris and I wanted to get there. Not because I was tired of this beautifully running engine ; far from it, but I was horribly thirsty, and had been ever since leaving Lille. My notes are plaintive : "So dry I can't spit !" A vision of "La Maison Blanche" floated before me as we swept through St. Denis ; the tracks multiplied, "push-and-pulls" were met or overhauled, Paris and *rafraichissement* were near at hand. The train came to a stand in the Gare du Nord at 7.30 p.m., dead on time ; 115·5 miles in 127 min, from Arras, 54·8 m.p.h. A perfect run on a very fine engine, capably handled by the whole crew, but not such as really to bring out the possibilities of the machine, which could easily have done just as well with a 50 per cent greater load. The high-light had been the beautiful condition of the engine, which only stood out the more plainly when compared with that of the observer : this was unsatisfactory.

(*To be continued*)

German Industries Fair, Hanover

No. I

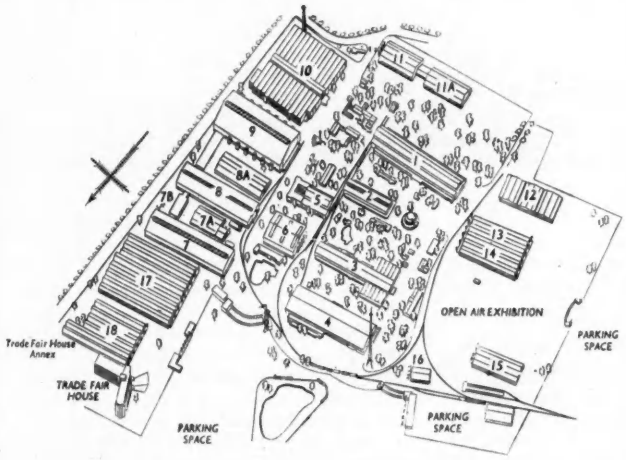
THE German Industries Fair, which opened on Sunday, April 25th, and closed on Tuesday, May 4th, successfully combined the Light and Heavy Industries Fairs in a single event which enabled a cross section to be seen through all the various branches of German industrial activity. Although, again this year, there were no heavy machine tools, as they will only be shown at the International Machine Tool Exhibition which will take place in Milan from September 14th to 23rd, the enlarged exhibition space in the halls and in the open air were nearly all filled.

The opening ceremony was held in the main restaurant in the fair grounds and the first speaker was Landesminister Alfred Kubel, the chairman of the Deutsche Messe und Austellungs A.G., who welcomed the representatives of the Federal Government and the Government of Lower Saxony, and the many visitors from public and economic institutions at home and from abroad. In asking Professor Dr. Ludwig Erhard, the Bundesminister for Trade and Commerce, to make a formal opening speech, he referred to the interest which had been taken by Dr.-Ing. Seebohm, Minister of Transport, in preparing and arranging the International Exhibition of Containers for Railway Transport, which formed an interesting feature of the Fair. The Hanover Fair would, he said, continue to play an important part in extending the export trade of Germany, the favourable position of which had been outlined by Dr. Hans Constantin Boden of the A.E.G., and President of the Foreign Trade Committee of the Federal Union of German Industry, in his address to the press, the previous evening.

In his speech, Professor Dr. Erhard declared that it would be the object of the Federal Government to restore the free convertibility of German currency whenever the convertibility of sterling was restored by the British Government. Speaking of the work of the European Payments Union, Dr. Erhard said that discussions had taken place, not only with regard to the work of the Union itself, but also on the position to be taken up by the various countries to achieve, if possible, free convertibility of currency within a measurable time. In his view a world-wide multilateral system would soon be possible and it would be necessary for Germany to increase her foreign investments. In conclusion, Professor Erhard advocated greater co-operation between European nations. His recent visits to South America had convinced him that narrow national aims in commerce were insufficient, and it seemed likely that more and more the idea of free competition was gaining ground in all countries.

The accompanying plan shows clearly the general layout of the exhibition space (Fig. 1). It will be seen that altogether twenty-five halls were provided in addition to the Trade Fair House, which along with its Annexe Hall 18, is set apart for the exhibition of china, ceramics, and glass, jewellery, silverware, watches and clocks, domestic machinery and household equipment. The total covered space in the halls is 200,000 square metres and that of the open-air spaces 55,000 square metres. The number of firms exhibiting was about 3891, of which about 2775 represented the heavier industries.

In the following article we give an account of some of the exhibits of special engineering interest.



1—Pumps, air conditioning and drying plants, valves and hoisting machinery.
2—Power transmission and gearing.
3—Prime movers, welding plant and machines for the ceramic industry.
4—Food processing machines, machines for rubber and plastics and testing machines.
5—Precision tools and gauges.
6—Chemicals and plastics.
7, 7*A* and 7*B*—Textile machines and machines for the clothing and laundry industries.
8—Woodworking machine tools.
8*A*—Precision tools and measuring instruments.
9, 10 and 11—Electrica machinery and equipment.
11*A*—Radio, television and photographic equipment.
12—Compressors.
13—Fine mechanisms and optical instruments.
14—Rubber and asbestos machinery and plant.
15—Conveyors and transporters.
16—International exhibition of containers for rail transport.
17—Office and business machinery and drawing-office equipment.
18—Domestic machinery and appliances.

Fig. 1—Site Plan of the Hanover Fair

Mannesmann

A 140m Mannesmann lattice tower, built of seamless steel tubing (see Fig. 2), has been constructed by the Deutsche Mannesmanröhren-Werke A.G. of Düsseldorf, to house the combined sales departments of that firm and the Mannesmann-Hüttenwerke A.G. of Duisburg. The total weight of metal used in the tower is about 32 tons and the erection was completed in three weeks. For this work from six to eight men were required, half being engaged in the actual erection work and the other half on the ground serving the lifting winches.

As will be seen from the drawing (Fig. 3), the plan section of the tower is an equilateral triangle. At the base it has a side length of 18m. This length diminishes in a parabolic form to 2m at the top. The three corner tubes extend to a depth of 4m below the

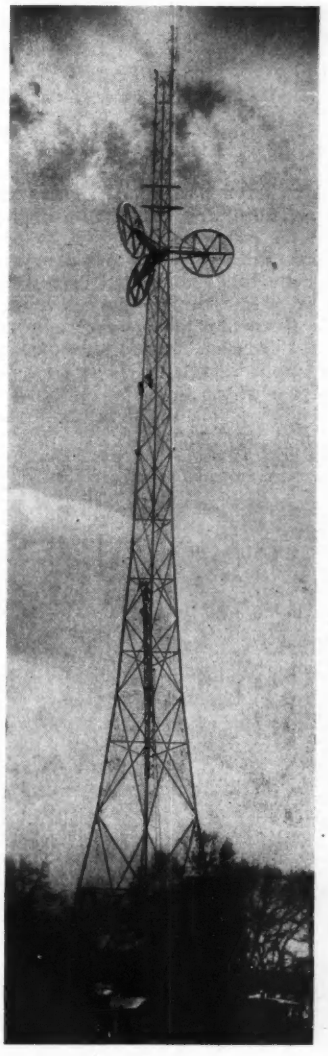


Fig. 2—Lattice Tower of Seamless Steel Tubing

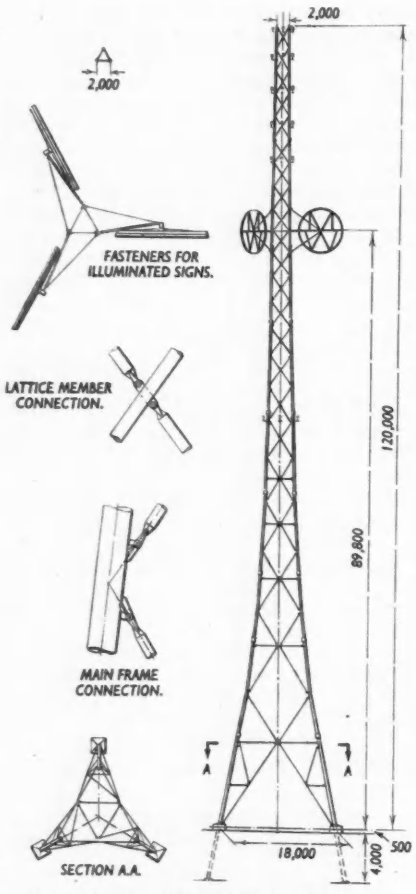


Fig. 3—Design of Steel Tubing Lattice Tower

top of the foundation and on each tube there are welded a number of shearing rings to take the vertical load. These corner tubes are filled with bitumen up to the top face of the concrete foundation to prevent the penetration of water and danger from damage by frost or internal corrosion. A check screw in each pipe just above foundation level enables the presence of water to be easily detected. The dimensions of the corner tubes vary from 241mm by 18mm at the base of the tower to 76mm by 8mm at the top of the tower. The corner tubes are built up in lengths of 12m to 15m and connected by screwed muff couplings of water-tight design.

The diagonal members on each face of the structure are parallel to each other. They are secured to the corner tubes by screws or bolts passing through a fitting bush embracing the two cheeks of a forked member on the ends of the diagonal strut, which engages a tongue member welded to the corner tube. The joint is made through a close fitting high quality steel bush of 30mm by 4·75mm tube. For fitting purposes this bush is mounted on a conical ended drift and the driving member is superimposed. The conical end of the drift is inserted into the hole in the joint and the bush follows the self-aligning conical drift. The bush is designed to take the full load of the diagonal strut and the securing screw gives additional strength. This method of assembly facilitates quick erection. The two conical ends of the strut are hermetically sealed and the forged steel forked members are welded on to them.

The erection of the tower was carried out using an auxiliary mast of screwed members, which were assembled in position, and this mast followed the tower as assembly proceeded. The heaviest weight to be lifted was about 1 ton. At the foot of the tower a pavilion has been built, which is reached by a wide spiral staircase.

At the top of the tower a further mast has been erected as an 8m high antenna for the Hanover Police, and was used for radio traffic control to and from the Fair. In addition to an illuminated sign (Fig. 4) on the tower there were fitted additional rings of red warning lights for aircraft. The photograph, Fig. 2, and the drawing, Fig. 3, clearly show the general design and appearance of the tower. The Mannesmann interests in Great Britain are represented by Mannex (London), Ltd., 66, Victoria Street, London, S.W.1.

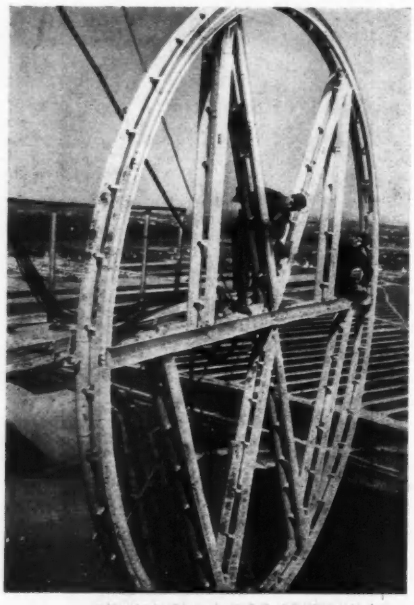


Fig. 4—Attaching Fluorescent Tubes and Electrical Connections for Illuminated Tower Sign

Kampnagel Aktiengesellschaft

An interesting new level luffing crane, designed for harbour and shipyard work and for portal cranes on dry docks, was demonstrated by the Kampnagel A.G. of Hamburg-Lübeck. It is built in various sizes with lifting capacities from 3000 kg to 5000 kg at radii from 20m to 36m. The crane exhibited, which is shown in Fig. 5, is a 3000 kg model having a maximum radius of 20m and a minimum radius of 5m. The jib is constructed on the straight lattice principle in the form of a two-armed lever, see Fig. 6. The centre of rotation is arranged through the centre of gravity, giving a perfect balance in each position. The upper crane house accommodates all the electrical apparatus and auxiliary machinery. The crane portal is of welded box-form with girder construction and it occupies but little space on the quay. On the land side the two legs are designed to permit free passage of traffic while on the water side the two legs are connected by a beam carrying the crane travelling gear driving the traversing wheels at both corners of the water side portal. The operation of the luffing system is clearly shown in Fig. 6.

During the movement of the jib, the lift of the compensating weight is proportional in height to the variation in the height of the centre of gravity and the jib sheave. The compensating weight is a combination of the jib weight and the proportion of the lever arm lengths. The horizontal load path during luffing is achieved by transmitting the lift of the compensating weight on to the lifting drum, which is carried out by means of an auxiliary rope and a sun and planet gear wheel, with a transmission ratio corresponding to that of the lift of the compensating weight and the vertical lift of the jib sheave. By accommodating all this equipment inside the lifting gear and within the column below the crane house, all parts are well protected and are easily accessible for maintenance purposes.

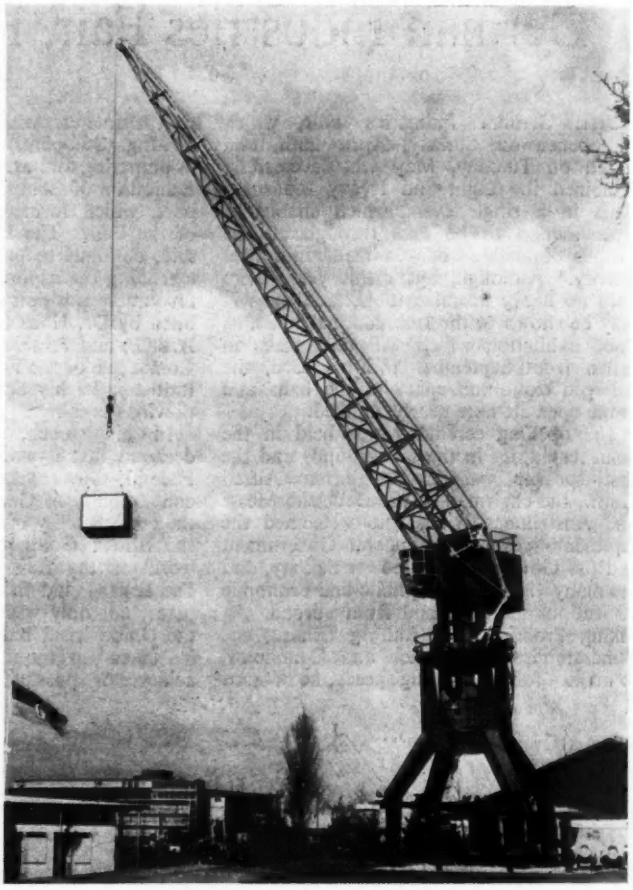


Fig. 5—3-Ton Level Luffing Harbour Crane

Miag Muhlenbau und Industrie G.m.b.H.

On the stand of Miag Mühlenbau und Industrie G.m.b.H. of Brunswick a complete bearing ring for a cement furnace was shown —see Fig. 7. The diameter of the furnace drum is 2·8m and as will be clearly seen, it is supported on two flat rollers. Each roller has a diameter of 900mm and a width of

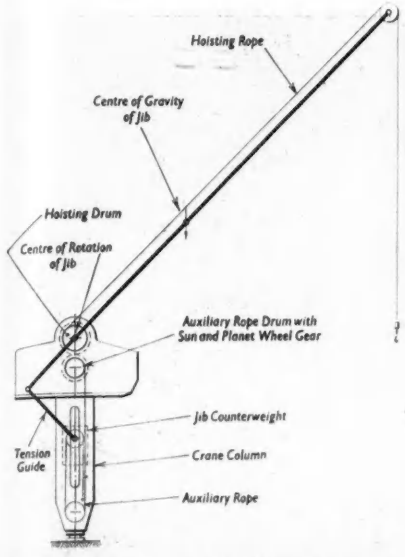


Fig. 6—Principle of the Luffing System and Rope System and Rope Compensation of the Column-Guided Quick Level Luffing Crane

400mm. These rollers run in a water bath. The bearings are also water cooled and they have a diameter of 355mm and are provided with scoop lubrication. On either side of the main roller bearings are two roller blocks, the forward block being clearly shown in our illustration. They are of flat form with an inclined bearing surface which bears against the sloping side of the heavy supporting ring on the furnace drum. These

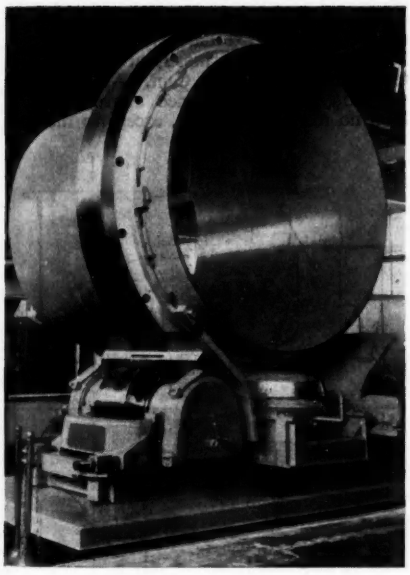


Fig. 7—Bearing for Cement Furnace

rollers effectively limit the end movement of the furnace. They are all cast in electro-cast steel. On the stand were models of the Portland cement works as well as of foundry products and milling machinery for grain and cocoa. The Miag Company is represented in Great Britain by D. M. M. (Machinery), Ltd., of 66, Victoria Street, London, S.W.1.

(To be continued)

SWEDEN'S ENGINEERING INDUSTRY.—It is stated that in the month of February employment in the Swedish engineering industry, based on the number of working hours per week, increased by about 1 per cent and was only 0·4 per cent below the figure for February, 1953. The largest increase, 3 per cent, was recorded in the electrical section of the engineering industry.

Marine Auxiliary and Emergency Gas Turbines

Details are given of the design and development of a 200 h.p. emergency gas turbine for naval use. A combined impeller and radial flow turbine having a common disc has been adopted, the rotor speed being 23,000 r.p.m. and the inlet gas temperature 780 deg. Cent. Mention is made also of a larger and modified design using axial turbines.

IN 1950, W. H. Allen, Sons and Co., Ltd., in collaboration with the Admiralty, commenced preliminary design studies for a small light weight emergency gas turbine-driven generator for naval requirements and a contract for a 200 h.p. unit was placed with the company in August, 1951. The engine was constructed and assembled by the end of 1952, since when a comprehensive series of performance, governing and endurance tests have been carried out in the company's test house at Bedford.

Description of Set.—Due to the limited length of running time expected from this design of engine, fuel consumption and long life were relatively unimportant considerations, and it was thus possible to construct a simple cycle, single-shaft engine. Also, in the interests of robustness and simplicity, the engine embodies a single stage centrifugal compressor, a single combustion chamber and plain bearings. The compression ratio was limited to 2·5 : 1 so as to enable a single stage turbine to be used.

The engine as erected for testing and coupled to a d.c. generator, is shown in Figs. 2 and 3. The view in the left-hand illustration shows clearly the single combustion chamber mounted on top of the main casing, and at the far end of the generator can be seen a Rotax cartridge starter.

Again from considerations of robustness, and because in the early development stage it was thought that a radial turbine might give a higher efficiency than an axial turbine in this small size, the radial flow type was chosen. In the design study it was found that a considerable amount of cooling air would be necessary on the disc face of the radial turbine, and thus emerged the idea of machining both the centrifugal compressor and the turbine from a single forging (Fig. 4). This idea appeared more attractive when it was determined from calculations that the cooling was so good that a ferritic steel (Rex 448) could be used. The heat transferred to the compressor resulted in an equivalent drop in compressor efficiency of approximately 1 per cent.

Originally, to avoid having a bearing in the hot exhaust gas, and to achieve the minimum overall length, the rotor was overhung, with two plain bearings running on a stationary stud shaft and the drive taken through the centre of it to the epicyclic gear. For reasons given later, the design was altered to provide a bearing on either side of the rotor, as shown in the sectional arrangement drawing, Fig. 1.

As can be seen in Fig. 1, air enters the centrifugal compressor from trunking above the set and, on leaving the diffuser, it enters the main air casing, which is connected to the outer annulus of a reverse-flow combustion chamber of the normal flame-tube Shell design.

A similar combustion chamber is shown in more detail in Fig. 6. The combustion chamber discharges into a volute which feeds the radial turbine. The main air casing surrounds this hot volute, so that the only " hot " part of the engine is the exhaust pipe.

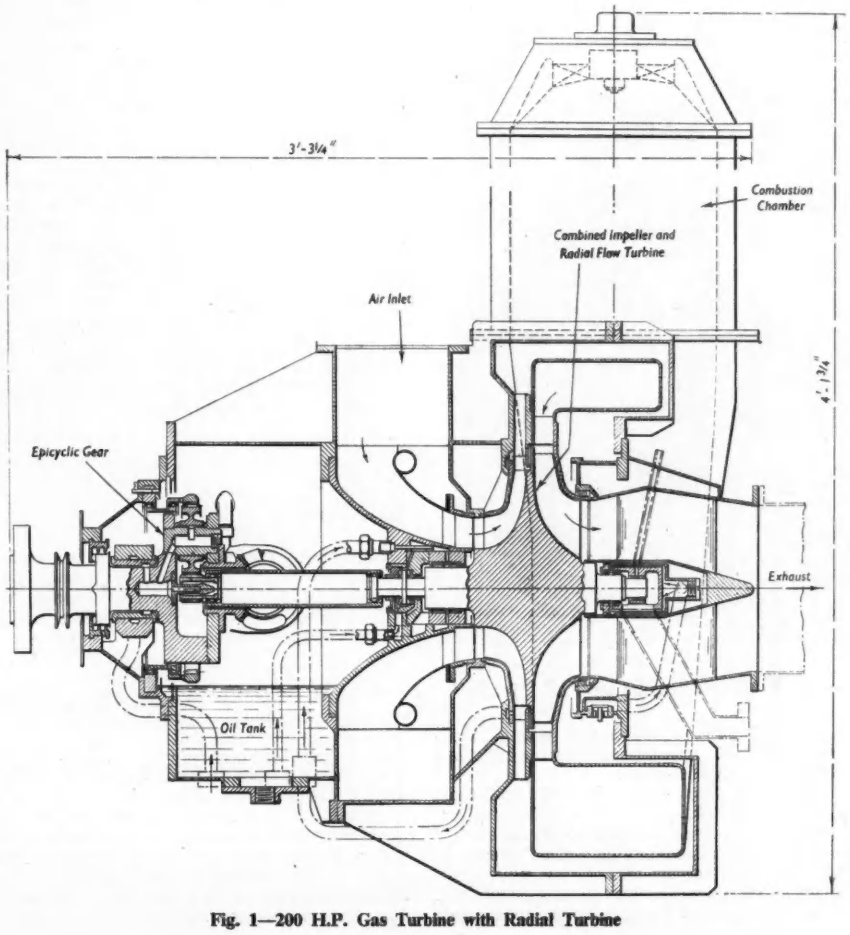
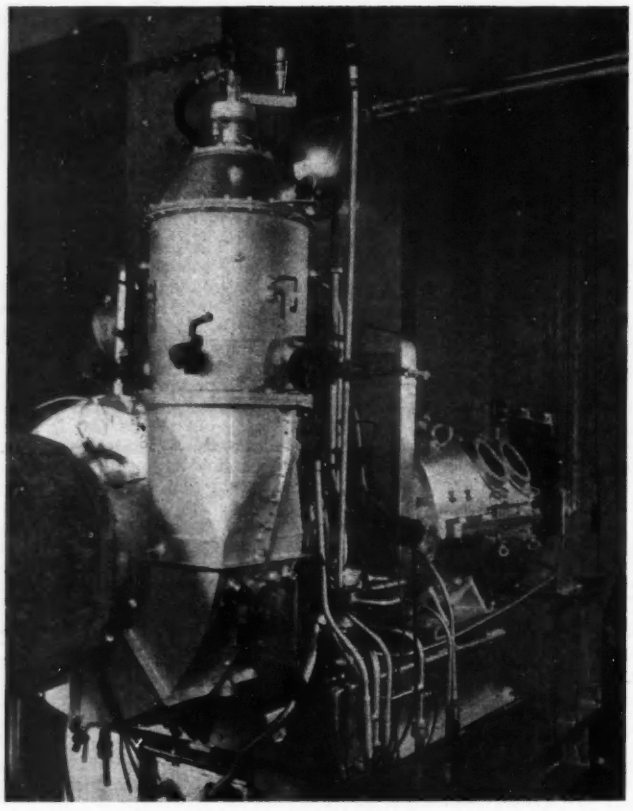
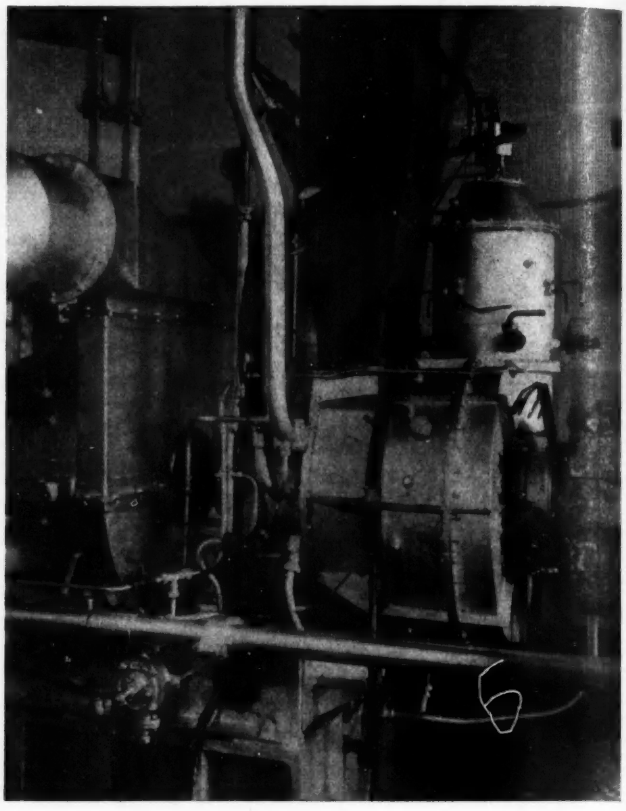


Fig. 1—200 H.P. Gas Turbine with Radial Turbine





Figs. 2 and 3—The 200 H.P. Gas Turbine as Erected for Testing with Generator

The turbine rotor runs at a speed of 23,000 r.p.m., and drives the generator at 3000 r.p.m. through an Allen-Stoeckicht epicyclic gear, which is contained in the main engine casing. The design life of the rotor is 1000 hours at full load.

The overall dimensions of the engine are 49¾in high by 39¼in long by 34¼in wide, and its

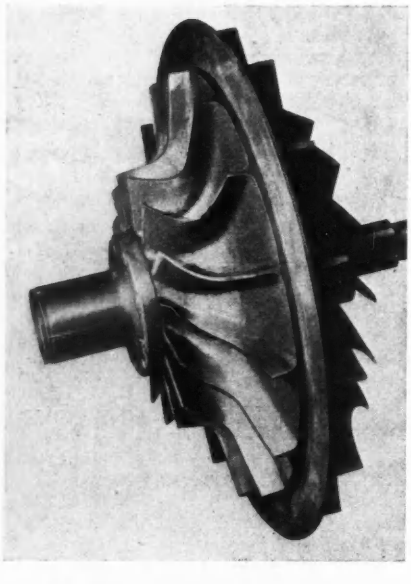


Fig. 4—Integral Impeller and Radial Turbine

weight, including reduction gear and all auxiliaries is 600 lb. It is mounted on the extension of the generator base-plate.

The burner (Shell design) is of the spill type, with a constant inlet pressure of 400 lb per square inch and a normal oil-operated speed control governor is fitted, maintaining the set at near constant speed (4 per cent droop no-load to full load) by moving a throttle in the spill line. An overspeed trip of the shock-proof unbalanced principle is situated on the fuel pump drive shaft, the pump being of a simple geared type.

Starting Procedure

It is necessary for Naval emergency gas turbines to start quickly and be self-contained, for which purpose a Rotax cartridge starter is fitted and has proved very satisfactory in operation. It has two 750 gramme cartridges firing on to a small turbine wheel, and the speed of the main rotor is taken up to 9000 r.p.m. in three seconds. The set then pulls away up to full speed when it comes under the control of the governor. The rate of this acceleration and the speed control adjustment of the governor is obtained by adjusting the blow-off pressure of the pump relief valve. A device will be fitted to prevent overfuelling of the engine and consequent overheating. The ignition of the flame is achieved in one of two ways : (*a*) with a simple sparkler inserted in the combustion chamber (this has proved completely reliable), or (*b*), with the Napier-Plessey high-frequency ignition unit.

Performance.—The following is the present measured full load performance :—

Air inlet temperature	60 deg. Fah.
Output	200 h.p.
Turbine inlet temperature	780 deg. Cent.
Mass flow	5·1 lb/sec.
Pressure ratio	2·4
Specific fuel consumption	1·6 lb/h.p./hr.
Thermal efficiency (high-speed coupling)	8¾ per cent

Governing.—The single shaft design makes governing easy and the set accepts the imposition or removal of full load (200 h.p.) with a temporary speed change only ¼ per cent in excess of the permanent speed change.

Development Testing

The first attempt to run the engine was not entirely successful, because the amplitude of the whirl which occurred when the rotor ran up through its critical speed (7000 r.p.m.) was so great that the turbine rotor blade tips rubbed on the casing. The reason for this excessive amplitude was not understood, and it was therefore decided to change to the present design with a bearing on either side of the rotor, with the result that the engine now runs well below its critical speed at all conditions. The initial fears for the bearing running in the hot exhaust gas stream have proved completely unfounded.

Running of the engine continued throughout most of 1953, and to date, well over 800 hours have been completed, mostly at a turbine inlet temperature of 730 deg. Cent. Apart from the vibration trouble mentioned above, there has been no mechanical defect, except to the flame

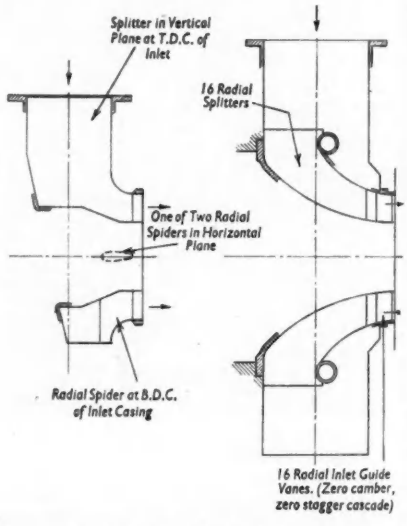

Splitter in Vertical Plane at T.D.C. of Inlet
16 Radial Splitters
One of Two Radial Spiders in Horizontal Plane
Radial Spider at B.D.C. of Inlet Casing
16 Radial Inlet Guide Vanes. (Zero camber, zero stagger cascade)

Fig. 5—Original and Redesigned Compressor Inlet Casing

tube (see below), no part has been replaced and the growth of the rotor has been negligible.

The efficiency of the radial turbine has been established as 86 per cent, but it is not superior to an axial turbine of this size.

The combustion chamber was first tested on an atmospheric rig by Ricardo, Ltd., and, later, developed by Shell on a pressurised rig to meet the design conditions of the engine. When engine running commenced, some minor alterations to the settings of components were necessary to allow for differences between the design conditions for the engine and its actual running

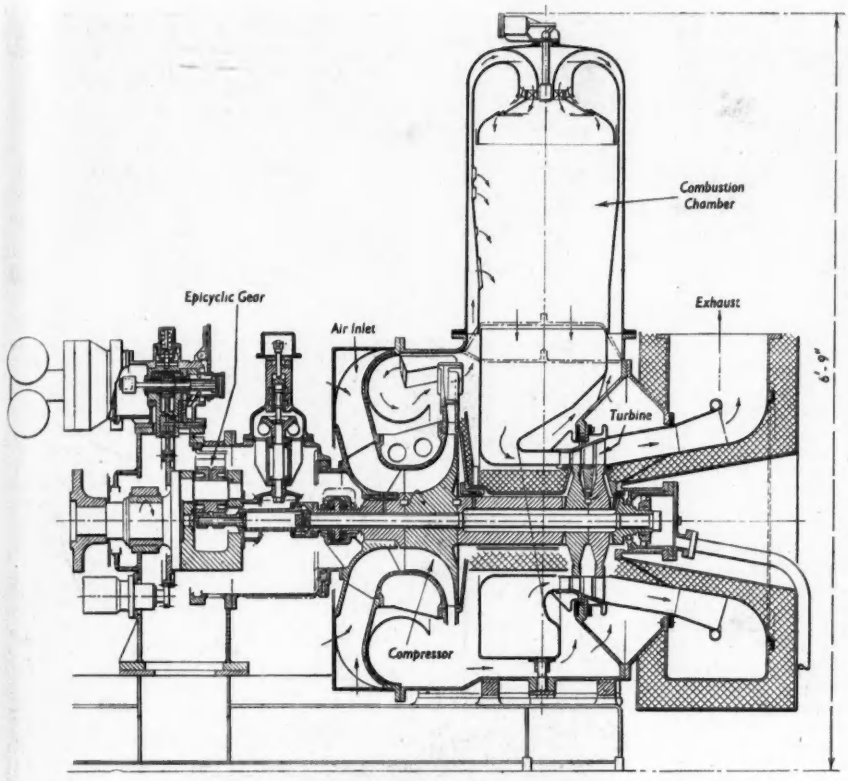


Fig. 6—350kW Gas Turbine with Axial Turbine

conditions. Distortion and cracking between the mixing-air holes of the flame tube was cured by introducing an axial air bleed just upstream of these holes. After 750 hours' running, the revised flame tube remained in excellent condition. On a compact unit of this kind the air entry to the combustion chamber is necessarily constricted and asymmetrical; this has had an adverse effect on the temperature distribution at the combustion chamber outlet. Work on this is continuing.

At a turbine inlet temperature of 730 deg. Cent., the horsepower obtained initially was only 123 h.p. and necessitated a considerable amount of work on ways and means of increasing this output. It was soon clear that the compressor was the cause of the trouble, as both the mass flow and the pressure ratio were below design value. The first move was to open up the diffuser throat area, which made no difference at all. Attention was then focused on the main air casing, in which quite high air velocities were discovered. At the top, just leading into the combustion chamber, air was flowing in the reverse direction to that expected, apparently passing around the back of the combustion chamber from one side, and re-entering the air casing on the other. Some baffles were therefore put in the casing, roughly dividing the flow from the diffusers into four streams, each feeding a quarter of the combustion chamber air inlet annulus. The power improvement was, however, negligible.

Consideration was next directed to the compressor inlet (Fig. 5), and the inlet casing was flow tested on a rig. It was soon seen that conditions were very bad here, as there was considerable breakaway behind two side support struts, which were just in front of the impeller, and angles of whirl up to 20 deg. were measured. The air was, therefore, obviously not entering the impeller axially, and the degree of whirl represented the angle of incidence on the impeller inlet vanes. Tests were made on a modified inlet casing and the one shown in Fig. 6 was found to be satisfactory, the maximum angle of whirl having been reduced to 4 deg. As can be seen, the approach annulus has been lengthened, and a number of radial plates provided to ensure that the tendency for the air to whirl at the sides is destroyed. The vanes at the sides were curved upward at the inlet. A cascade of zero incidence blades were also placed at the entrance to the impeller, but it is doubtful if these are necessary, as without them the maximum incidence (or whirl) was 7 deg. Fig. 7 shows both the old and the new whirl distributions and Fig. 8 the old and new velocity profiles.

When tried on the engine the new casing gave disappointing results, as the output was increased by only 7 h.p. to 130 h.p., but it may be that the value of this modification was not felt until later when the impeller itself had been altered. It now seemed clear that the cause of the trouble was in the impeller itself, and that there was insufficient flow area in the passages. The modifications shown in Fig. 9 were then made, i.e. the disc profile was altered to allow an increase of flow area, and the vanes were thinned. This brought a marked improvement in power output of some 25 h.p. to 155 h.p. It was not possible to go further with this line of thought with the present impeller. It was found that the power could be increased to 165 h.p. by increasing the rotational speed from 22,000 to 23,000 r.p.m. Previously this speed increase had given no power increase. The impeller inlet ears were unbent a little, giving a slight increase in entry throat area, and a few degrees of positive incidence. This had only a small effect, but it was in the right direction and the power output rose to 170 h.p.

Following the completion of 750 hours' running at 730 deg. Cent. turbine inlet temperature, with a negligible growth in rotor dimensions, it was decided to increase the turbine inlet temperature, and endurance running at 800 deg. Cent. is now under way—power output being 212 h.p.

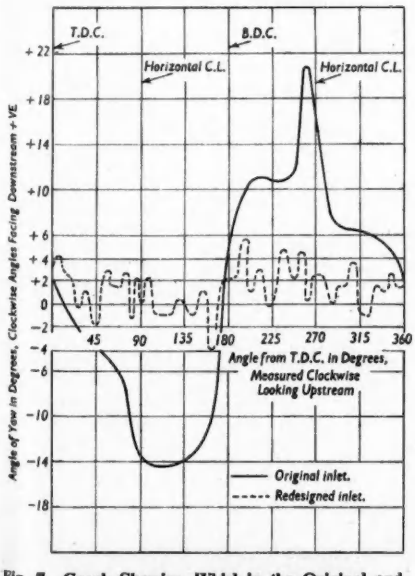
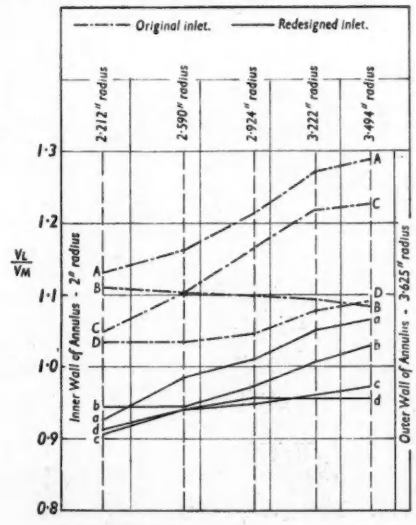


Fig. 7—Graph Showing Whirl in the Original and Redesigned Compressor Inlets



V_L = local velocity.
V_M = mean velocity based on mass flow.

Original inlet	Redesigned inlet	Circumferential station
A	*a*	315 deg. from T.D.C.
B	*b*	45 deg. from T.D.C.
C	*c*	135 deg. from T.D.C.
D	*d*	225 deg. from T.D.C.

Angles measured clockwise from T.D.C. looking upstream.

Fig. 8—Graph Showing Velocity Distribution Across Compressor Annuli

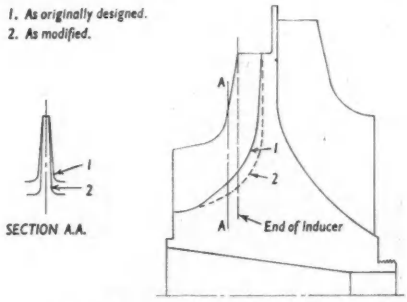


Fig. 9—Original and Modified Impeller

Development is still continuing and a new rotor with a modified impeller shape is to be fitted.

A larger gas turbine similar to the 200 h.p. unit has also been designed by W. H. Allen, Sons and Co., Ltd., and is now in course of construction. This larger version is being incorporated in six complete Allen gas turbine-driven d.c. generating sets which have been ordered by Alfred Holt and Co. for auxiliary use on board Blue Funnel liners, the rating being 350kW at an air inlet temperature of 85 deg. Fah. (30 deg. Cent.). These sets are too large to make efficient use of a radial-flow turbine, so the single-stage centrifugal impeller is driven in each case by a two-stage axial turbine. The design arrangements of this larger size of unit are shown in the sectional drawing illustrated in Fig. 6.

WELDING SHOP PLANT.—An exhibition of its mechanised welding shop plant is to be held by the Surrey Tool Development Company, Ltd., 156, Dalston Lane, London, E.8, from June 21st to July 14th, at 336, High Road, Wembley. The range of equipment to be exhibited will include manipulators, rotators, travelling rotators, columns with elevating arms to carry automatic welding heads, portable power units, pipe rotators, &c.

Nechells "B" Power Station

Some details are given of the Nechells "B" Power Station, Birmingham. Its four turbo-alternators develop a total of 210MW with steam conditions of 650 lb per square inch pressure and 825 deg. Fah. at the stop valve. The fuel burnt is a mixture of coke dust and coal.

ON Tuesday, May 4th, the Nechells "B" power station was formally opened by the Lord Mayor of Birmingham. The first of its four 52·5MW turbo-alternators was originally commissioned at this site in June, 1951, and these and ten of its twelve boilers are now operational. Considering the present trend in power-house practice, the station operates with the relatively modest steam conditions of 650 lb per square inch pressure at 825 deg. Fah. It is distinguished, however, by the consumption of a coal fuel mixed with over 20 per cent coke dust and a particularly low generating cost is achieved. Large quantities of coke dust are available from the nearby works of the West Midlands Gas Board. As this dust is normally almost a commercial waste product and therefore cheap to buy in comparison with coal, it was decided not to use pulverised fuel plant, but to install chain-grate stokers designed to burn a mixture of coal and coke dust. The original intention was to use a mixture of four parts of coal to one of coke dust, but in practice it has been found possible to burn satisfactorily a larger proportion of coke dust in the mixture, thereby reducing total fuel costs.

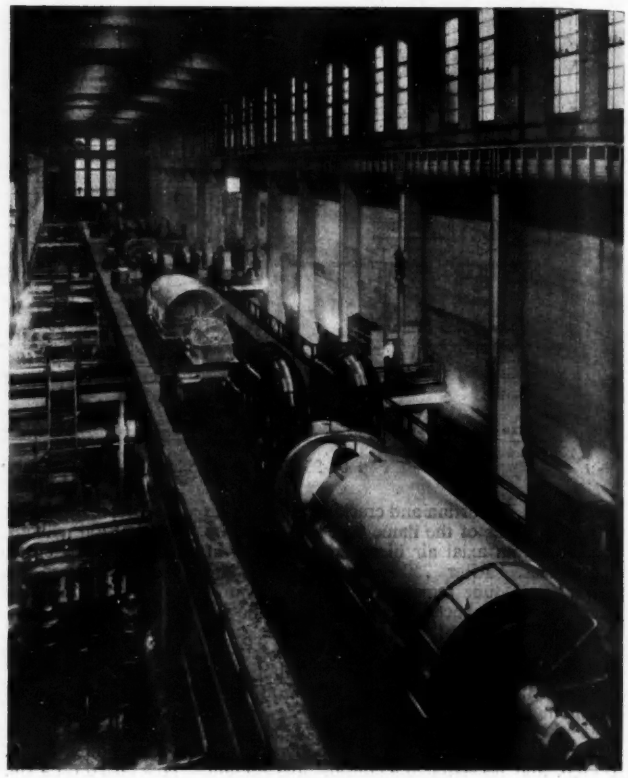
A further beneficial result from using chain-grate stokers is the ease of ash disposal. Stoker grate ash is a product for which there is a demand in the Birmingham area, and the station is able to dispose of ash for these purposes quite favourably. The difficulties that would be associated with the disposal of ash from a pulverised fuel plant on an urban site, restricted in area and with no ash dumping space in the immediate vicinity, can readily be appreciated at this particular station. Apart from this consideration, there is the increased capital expenditure associated with pulverised fuel equipment with its attendant electrostatic precipitation plant to minimise atmospheric pollution by fine ash particles that would otherwise be discharged from the chimneys.

Foundations and Buildings.—Site work was commenced in 1946 by Sir Robert McAlpine and Sons (Midlands), Ltd., and piling had to be adopted for all the foundations of the building, turbo-alternators, boilers and cooling towers. The main building housing the plant is of brick-panelled, steel frame construction. It is a little over 500ft long, nearly 400ft wide, 105ft high, and stands in a site area of 23 acres. C. Bryant and Sons, Ltd., were the main contractors for the building superstructure, the structural steelwork being carried out by E. C. and J. Keay, Ltd., who also erected the boiler fuel bunkers.

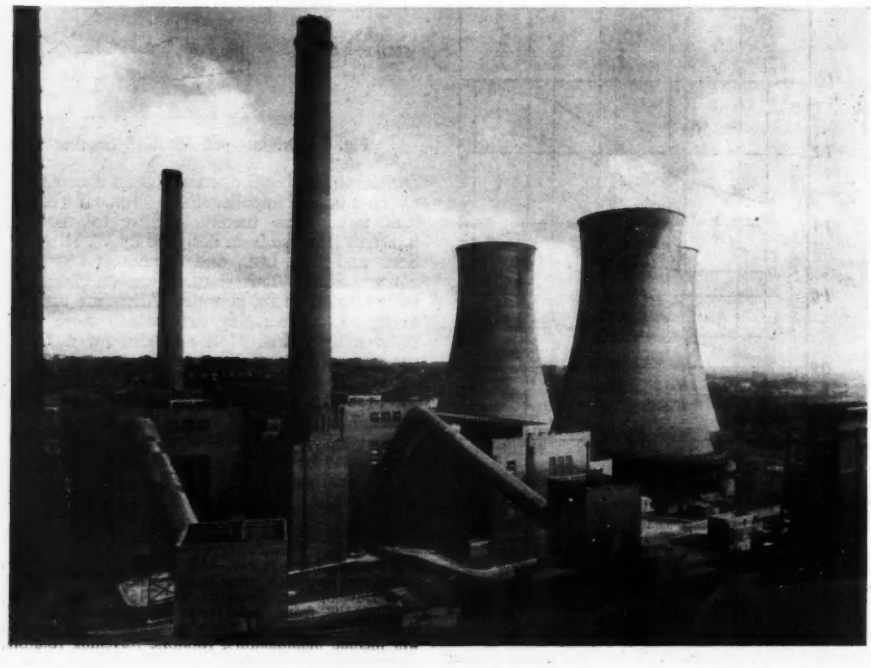
Plant Layout. — In the turbine room the machines are arranged in line, the two machines in the second half of the station being of opposite hand to those in the first half, giving shorter steam pipe runs, and the added advantage to the operating staff that the steam ends of Nos. 2 and 3 machines are adjacent. The turbine operating floor, standing 18ft above ground or basement level, is carried the full length of the station. Between the turbines and the boilers is the heater bay accommodating the feed heating plant, the unit evaporators and feed pumps, together with certain auxiliary plant.

The boiler-house contains two rows of boilers, with firing aisles arranged on the outside of each row and at the same level as the turbine operating floor. Between them is the fan bay containing the induced and forced draught fans and motors, with their associated induction regulators, the main flues and the grit collectors. This plant is located on three levels, the forced draught fans being mounted on two galleries running the length of the station behind the boilers and the induced draught fans at the firing floor level. Below this level are the grit collectors and the main flues, the arrangement of the flues permitting a chimney at each end of the station, centrally disposed between the two lines of boilers.

Coal-Handling Plant.—The coal-handling plant, installed by Mitchell Engineering, Ltd., comprises two sets, one for each line of boilers, of duplicate wagon tipplers, gravity bucket conveyors, and inclined belt conveyors, with shuttle belt conveyors built over the coal bunkers. The plant is designed to handle standard railway wagons of between 8 tons and 20 tons capacity and each of the wagon tipplers, with their associated conveyors, will elevate fuel to the bunkers at the rate of 120 tons an hour. The coal and coke mixing hoppers are situated at the top of each of the gravity bucket conveyor houses, which ensures adequate mixing of the fuel before it passes to the belt conveyors.



Turbine Hall



Nechells "B" Power Station

Boiler Plant. — The steam generating section of the station consists of twelve boilers, manufactured by International Combustion, Ltd., each having an evaporation of 230,000 lb per hour from feed water at the economiser inlet at 340 deg. Fah. The steam conditions at the superheater outlet are 675 lb per square inch and 850 deg. Fah. Each unit comprises radiant boiler, superheater, economiser, air heater, stoker, draught plant and grit collecting plant.

The stoker is of the twin "L" pattern, 32ft wide and 22ft long with a rating of 46·2 lb of fuel per square foot per hour. This is set in a "Lopulco" fin tube combustion chamber with a short refractory front arch and completely cooled rear arch. The combustion chamber volume is 9800 cubic feet with a rating of 2800 British thermal units per cubic foot per hour. The boiler drums are four in number, including a steam receiver.

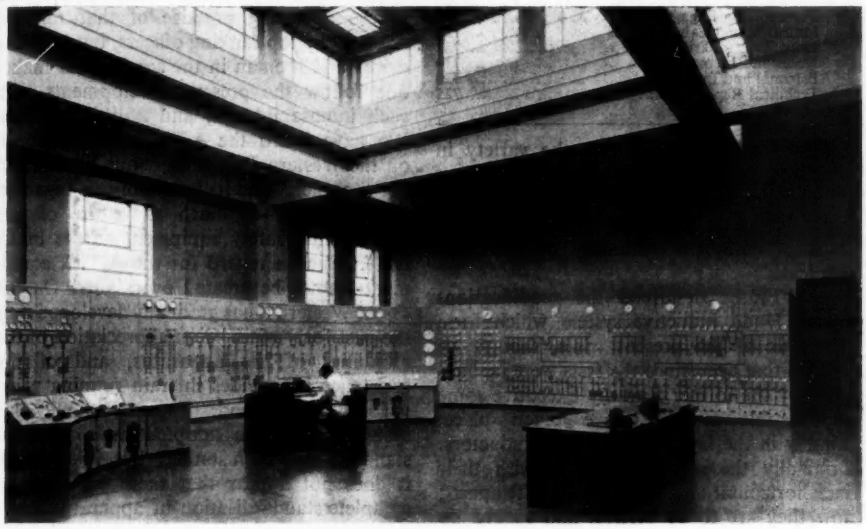
Superheating is effected by means of horizontal tube drainable elements coupled to headers, the primary inlet elements being connected through the steam receiver to the steam drum. Steam

temperature control is by means of a gas by-pass damper. The economiser has gas and water in contra-flow and is of the steaming type, three banks high.

The draught plant comprises two induced, two forced and two secondary air fans per boiler. Air for combustion is taken from the top of the boiler-house to assist ventilation and is then passed through a plate air heater arranged for air recirculation. The forced and induced draught fan motors and the motors for stoker drive are all variable-speed a.c. commutator motors, speed control being exercised by induction regulators.

The boilers were designed to burn the mixture of coal and coke dust already referred to in the proportion of 4 to 1, the fuel having a gross calorific value of 9758 British thermal units per pound, with 12·2 per cent moisture, 17·3 per cent ash and a volatile content of 22·3 per cent. The overall efficiency on the gross C.V. was guaranteed to be 83·5 per cent at maximum continuous rating. This figure was, however, improved upon by a small margin on the official acceptance tests. Fuel consumption is about 14 tons per hour.

Turbo-Alternators.—The generating plant consists of four 52,500kW turbo-alternators, each complete with its own surface condensing and



Control Room at Nechells "B" Power Station

feed water heating plant, manufactured by C. A. Parsons and Co., Ltd. The turbines are of the three-cylinder design driving, at 3000 r.p.m., a main 50,000kW alternator and a 2500kW auxiliary alternator. They are designed to operate with steam at a pressure of 650 lb per square inch at a temperature of 825 deg. Fah. A separate steam chest mounted alongside the turbine contains two governor valves and a separate emergency stop valve, all valves being operated by oil from a pump driven from the end of the h.p. turbine shaft.

The steam expands in the h.p. cylinder down to approximately 135 lb per square inch when it is led through a pipe, below the operating floor level, to the i.p. cylinder, where it is expanded down to 13·0 lb per square inch and then finally through two overhead pipes to the l.p. cylinder, where it is further expanded down to the exhaust vacuum of 28·5in Hg. at economical load. Steam for feed water heating is tapped from the turbine at four points where the absolute pressures at full load are about 180 lb, 64 lb, 16 lb and 6·5 lb per square inch. This arrangement permits of the condensate being heated regeneratively to a temperature of 357 deg. Fah. when the turbine is developing its maximum rated output.

A double-inlet single condenser has a cooling surface area of 60,000 square feet and requires 40,000 gallons per minute of cooling water, arranged to flow in two passes. The associated pumping plant consists of five vertical spindle motors, driven by 3·3kV slip-ring induction motors, totalling 1900 h.p. There are three cooling towers (as illustrated opposite) built by Fred Mitchell & Son, Ltd.

The main alternators are designed for a voltage of 11kV and 0·8 power factor at the busbars. The exciters for the main and auxiliary alternators for each machine are located alongside the alternator foundation block at basement level. These are motor driven at a nominal speed of 1000 r.p.m., the auxiliary or pilot exciter being mounted on the same shaft as the main exciter. The pilot exciter supplies the field of the latter at a constant voltage, thus ensuring electrical stability.

The cooling of the main alternator is effected by means of two separately driven fans operating on a closed circuit. The air coolers are accommodated in the alternator foundation block and are provided with water from the condenser circulating water system.

A separate live steam evaporating plant made by Aiton and Co., Ltd., provides an auxiliary supply of 25,000 lb of distilled water per hour.

Ash-Handling Plant.—The ash from the boilers is sluiced by a continuous closed-cycle water system to a large settling sump. The sluices are arranged to give a gravity flow from each end of the boiler-house toward the centre and thence to the sump. There are three lines of sluices to each line of boilers, handling respectively rough ash, riddlings and the grits caught by the grit collectors.

Main and Distribution Switchgear.—Because local industry within a radius of 2 to 3 miles will absorb most of the power generated at the station, the alternators generate at the distribution network voltage of 11kV. Provision for interconnection with the grid system is, of course, arranged.

The main 11kV switchgear controlling the output of the first two machines comprises two groups of G.E.C. cellular gear located in the "A" station, which has been up-rated to 1000MVA. The switchgear controlling the third and fourth machines comprises two groups of G.E.C. metalclad gear, also of 1000MVA rating, which is located in the "B" station building.

Control Room.—In the control room the main mimic diagram remote control switchboard, which is 102ft long, is arranged in a semi-circle around the control desk, with the 3·3kV control board for the works supply on the opposite side of the room. The control desk is divided into two portions, which are separated by a central logging desk. The control desks accommodate load and voltage control for the machines, grid transformers and group feeder booster reactors, but all switching and synchronising is carried out from the appropriate main control panels. All the equipment in this room was installed by The General Electric Company, Ltd.

Hundred Years of Development in Mechanical Engineering*

By GEORGE CONSTANTINESCO, Hon.F.S.E.

THE mechanical engineer during the past hundred years fell between the rough and ready rules of thumb based on the experience of the ancient craftsmen and the highly developed theoretical mechanics. Fundamental progress, however, was made possible by the work of free-lance inventors who threw theories overboard and relied on their inspiration, faith, skill and experiment as the final arbiter for success or failure. It is by this process of knowledge derived from research in the workshop with materials in motion that they developed their own kind of science and even mathematics, which may lack in rigour but was more adaptable to realities. The mechanical engineer has gone so far in this field that he has surpassed his colleagues in physics. It is interesting to find that compared with a hundred years ago, when mechanics humbly begged science to give a helping hand, the situation to-day is completely reversed.

* * *

The progress of mechanical engineering during the past hundred years was not due to the discovery of new mechanisms. The great majority of the means and components known to engineers and ready for mechanical applications, as the needs arose from time to time, were already at hand. Something much more important has happened and which may be described as a major revolution in the way of thinking by engineers. A great deal of capital is made of the impact of science on the development of mechanical engineering, but if one goes deeper into this matter he will find not only that science has contributed little to such progress, but that, in fact, the impact was in the reverse direction. During the past hundred years it was the development of new inventions in mechanics which has prodded science out of its contented delusion that all that was worth knowing was already known, and stirred it into a perplexed but new and vigorous life.

* * *

Mechanical engineers must know what they are talking about when planning. Nothing else will do, except that their machines should perform truthfully according to their plans. With the advent of the new theories in physics that mass is not invariable, and that impulse or momentum and position have become subject to indeterminism, there is frank admission by scientists that they are bewildered and have to take refuge from reality in the paradise of mathematical expressions. But there is danger that mechanical engineers may fall into this mathematical emptiness that may lead nowhere instead of everywhere. Mechanics have to deal with realities, and mathematics are only a shorthand notation for rational logic. There are signs that this kind of logic leads to an empty world in which the stars are vanishing beyond the beyond.

* * *

Mechanical engineering has nothing to fear from the humiliation of science knocking at the gates of the temple of faith. On the contrary, these gates are there, not to keep visitors out, but to show them where there is a way in. Men of mechanics have at all times of difficulty taken inspiration from the things themselves. They have adopted science where science fitted. Where it did not, they made their machines without it, just like discarding a spanner which did not fit. They forged other tools. Thus a very large encyclopædia of mechanical experience and knowledge was accumulated, surpassing in many quarters the scientific knowledge available. Mechanical engineers were able to achieve the impossible many times, long before the science of the time could help them in any way. This is why mechanical engineering has leaned more and more towards being an art than a science and, as in all arts, the principal factors in achievement were intuition, invention, imagination and faith—in short, the faculties that make possible the impossible.

* Excerpts from an Address in Celebration of the Centenary of the Society of Engineers.

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A.T.C.: A SURVEY

In his presidential address to the Institution of Railway Signal Engineers on Wednesday, April 14th, Mr. J. H. Fraser, chose for his subject a survey of automatic train control methods. Particular interest and importance can be attached to this address as Mr. Fraser is Chief Officer (Signals and Telecommunications), British Transport Commission ; but at this stage there is obviously not a great deal that can be added to what is at present common knowledge of the subject. Various methods of obtaining the " link-up " between the indications displayed by the wayside signals and the mechanics of the train were reviewed, touching briefly upon the divergent practices used in France, Switzerland and Germany, and contrasting these with the work done in Britain so far and that in America. From a close analysis of these methods Mr. Fraser outlined afresh the reasons why the experiments on British Railways are being pursued in their present form. Naturally, reference was made to the system in regular use on the Western Region, which has given constantly reliable service for more than forty years and covers all main lines of the former Great Western Railway. In the past various oblique references have been made to the unsuitability of this system for general adoption on British Railways, but it now appears that the main difficulty is that of mechanical clearances on the motors of certain electric stock. There is also the possibility that in the case of new electric or diesel-electric locomotives, the designers will press for still more space to be allotted to gear carried on the bogies. Apart from the matter of clearance, we know that there are some who prefer an inductive " pick-up " for its own sake, in preference to a " pick-up " accomplished through a contact ramp. But the difficulties of those who seek to attain a new arrangement that shall eventually be standard throughout the British Railways are formidable indeed, since the variety in practice between the former independent railways, even in such a matter as vacuum braking, was profound, and will take generations of complete continuity of policy to eradicate.

Mr. Fraser described the modifications to the Hudd inductive system which form the basis of the present trials, though we learned that even since the tests were inaugurated by the former Railway Executive some considerable changes have taken place, notably in the layout of the track inductors. Originally these were mounted with their axes horizontal and spaced about 5ft apart ; now they are to be vertical and spaced no more than 2ft 6in apart. The first inductor, which is a permanent magnet, has its north pole uppermost, while the second, which is an electromagnet, presents a south pole uppermost when it is energised. As at present arranged the air gap between the locomotive receiver and the upper faces of the track inductors is no less than 5in. The north pole alone provides the impulse for a warning indication, while a north pole followed by a south pole gives rise to the " clear." With the inductors no more than 2ft 6in apart the time interval between successive reactions is no more than 0·02 second at 90 m.p.h., and we fancied that Mr. Fraser spoke a little feelingly when he referred to the dirt, to the racket, and to the general rough-and-tumble conditions under which an instrument of such sensitivity had to function. He referred also to the difficulty of finding a suitable place for the indicator. It might certainly be questioned whether the present experimental mounting on the faceplate, among pipes, cocks, and so on, is the best. The Great Western had standardised a very neat mounting at the driver's elbow quite apart from all other cab fittings, and a similarly convenient position had been found for the indicator in the original L.M.S.R. installation on the Tilbury line locomotives.

Much of Mr. Fraser's address was devoted to what may be termed the psychological aspects of A.T.C. We would agree that some important considerations are here involved. The fact that the principles incorporated in the system standardised on the former G.W.R. were accepted by the Pringle Committee of some twenty-five years ago, as a basis for a future national standardisation does not eliminate all desirability of those principles being reviewed again. Traffic conditions on British Railways are constantly in a state of evolution, and the importance of examining such proposals from every angle likely to be encountered in the diverse operating conditions found in different parts of this country cannot be over-stressed. But all the same it was rather astonishing to learn that the operating officers concerned are not entirely convinced of the need to give an audible signal at all when the distant signal is clear. It is perhaps the established success of the Great Western system, and a knowledge of the completeness with which the principles of the intermittent warning type of A.T.C. had been accepted in the operating practice of that railway, not only by top ranking officers, but by every driver and fireman in the service that makes one follow the present developments with such intense interest, and a little concern. We have heard the A.T.C. unit mentioned on the Western Region as " our little friend in the corner," and its functioning is regarded as sacrosanct—as much a feature of the fundamental safety equipment as the brake itself. Such a regard for the A.T.C. equipment cannot be created overnight. On the Great Western it has gradually developed over the past forty years by an appreciation of the reliability of the apparatus, and of the assistance it provides in train running when visibility is not good. The reasons why this system cannot be adopted as a national standard have been stated ; but, in any case, it does not appear that there can ever be complete standardisation in apparatus while the vacuum brake is used for long-distance passenger trains and the air brake is used for electrified suburban services. Standardisation may be no more than a distant ideal in this country so far as A.T.C. is concerned ; but whatever new systems are adopted in the near future, whether to suit vacuum or air-braked stock, they must gain the confidence of the footplate men by their unfailing reliability, whether on long-distance steam-hauled services, or on fast shorter distance electrics such as those running from London to Brighton, and Portsmouth.

ENGINEERS AND SCIENTISTS

The reputation of engineers has suffered much at the hands of scientists since the war ended. Again and again our profession has been upbraided for making too little use of scientific discoveries. Again and again we have been told that we take too long to apply them to useful purposes. Nor has it availed us to use the argument in our defence that engineers are not concerned solely to apply science but also to apply it economically. For—it is an awkward fact—the scientists can always point to this or that of their discoveries which, for long neglected, proved, when it was applied, economically successful and profitable to its user. The better tack for us to take is that recommended by the

military as the surest form of defence. Scientists are vulnerable to counter-attack. For the work of engineers has prompted and prodded them into making far more of those scientific discoveries that they now wish us to apply than they would ever have conceived possible had pure scientific curiosity been their only source of encouragement! Last Friday the Society of Engineers held a Centenary Banquet at the Fishmongers' Hall, which we were privileged to attend. Amongst a number of addresses presented by famous men in connection with that centenary was one by Mr. Constantinesco. He was downright in his opinion about the past. "The development of new inventions in machines . . . prodded science out of its contented delusion that all that was worth knowing was already known." The process still goes on. How much pure scientific knowledge would there be about the qualities of high-pressure high-temperature steam, the phenomena of fatigue, creep and corrosion, the propagation of flame, the powers of industrial catalysts, the nature of inorganic materials and literally hundreds of other things if engineers had not begun to make structures and machines despite their lack of knowledge of such matters; and if subsequently had not set their own fellows to study them and sometimes asked scientists for help?

Physicists and chemists seek by controlled experiments to establish fundamental relationships expressible with precision in mathematical form. Engineering advance comes about in quite a different way. Primarily it is founded upon insight and invention and a practical desire to try it and see if it works. Engineering progress, as Constantinesco put it, was, in the past, "made possible by the work of free-lance inventors who threw theories overboard and relied on their inspiration, faith and skill, and experiment as the final arbiter for success or failure." That, perhaps, is an exaggeration. Watt, Trevithick, and many others amongst the pioneers were glad to have such support as theory could offer in their day and more than ever, nowadays, inventors hesitate to "throw theories overboard." Yet it is just as true now as ever it was that scientists and theoreticians often impede rather than aid engineering advances. Often, when offered a suggestion by an inventive practical mind, they reach out to examine why it should not work rather than how it might be made to work. Zeuner, for example, in 1869 regarded the "thermic" engine as incapable of competing with steam because to do so the pressures within the cylinders (correctly computed by him) must be so high as to be deemed impracticable. Fortunately the pioneers were not dismayed, else there might be no internal combustion engines in use to-day. Theoreticians and scientists are, of course, seldom wrong. What they fail to allow for is the ingenuity and inventiveness of engineers when faced by difficulties that may seem insuperable to less practical minds; they lack the faith of engineers that if, at a first attempt, something can be made to work at all, then through successive development it can be immensely improved.

Let it not be thought, however, from the foregoing that we despise theory and regard the academic method as something to be forgotten as soon as a college course has been completed. Far from it! The part that ingenuity and practical inventiveness play in the advancement of engineering has been stressed only to show how, in a way different to that adopted by scientists, engineers, too, have made scientific discoveries; and in doing so, in being bold enough to build structures and machines empirically and without complete knowledge of stresses and strains and many other phenomena, they have stimulated at least as much advance in pure science as pure science ever stimulated in engineering. In truth scientists and engineers seek to attain similar results by differing means. The engineer is merely in the greater hurry. For the dam must be built, the pump constructed, the engine set to work whether or not precise theories are available upon which to base designs. Rules of thumb are essential guides when *ad hoc* experience is the only guide and ingenuity and invention the only roads to success. But the acquirement of more precise knowledge through scientific research and investigation necessarily leads to more advanced and more economical design. Thus in their desire to acquire precise knowledge scientists and engineers are as one. It is their approach, not their aim, that is different. But when scientists claim that engineers make too little use of their discoveries cannot the engineer retort that pure science often pays too little attention to solving problems that engineers most desire should be solved? It is true that it is difficult to decide where pure science ends and technology begins. But it is to the technologist rather than to the scientist that engineers look for the solution of most of their problems.

Obituary

F. A. WILLCOX

We have learned with regret of the death of Mr. F. A. Willcox, a director of J. and E. Hall, Ltd., Dartford, which occurred on May 7th at the Middlesex Hospital, London, at the age of eighty-three. Mr. Willcox was born in Lewisham and studied at Armstrong College, Newcastle upon Tyne, where he had a brilliant academic career. He was later awarded the degree of Doctor of Science by Durham University.

After leaving the university, Mr. Willcox was for a period a science master at Burton-on-Trent Grammar School, and then entered industry as an assistant engineer and chemist to the Smokeless Powder Company. He subsequently became manager of the military powder department of the American E.C. and Shultze Company. On returning to this country, Mr. Willcox joined his brothers in the firm of Willcox Brothers, of Sunderland, who were, and still are, agents of J. and E. Hall, Ltd. Here Mr. Willcox had a great deal to do with the early development of refrigeration on trawlers. He joined J. and E. Hall, Ltd., in 1909, and two years later became technical director. Later he became director in charge of the financial side of the organisation. When the company's benefit trust was inaugurated by the late Mr. Everard Hesketh in 1912, Mr. Willcox became its first chairman, and except for a few short intervals he retained that position up to the time of his death. It is a trust administered by a committee of employees for the benefit of those who encounter hardship through sickness or for other reasons.

Mr. Willcox had been a member of the Institute of Refrigeration since 1910 and in 1935 became its president, his chief interest throughout being in the education of the young refrigerating engineer. He was also a member of the Institution of Chemical Engineers and for some years served on its council.

Another direction in which Mr. Willcox's expert services were called upon was in connection with the Food Investigation Board, set up by the D.S.I.R. during the first world war. Mr. Willcox became a member of the Board's engineering committee, a position which he held for more than twenty-five years.

Mr. Willcox took a keen interest in many local affairs in and around Dartford. He was a member of the governing board of Dartford Technical College and served as its chairman for several years.

W. HANNEFORD-SMITH

We regret to have to record the death of Mr. William Hanneford-Smith, which occurred, after a short illness, on May 7th, at 6, Lennox Avenue, Gravesend. Mr. Hanneford-Smith, who was seventy-six, studied in his youth for an engineering career, but subsequently decided to enter the book publishing business. He spent by far the greater part of his long working life with the firm of B. T. Batsford, Ltd., of which he was a director, having retired only recently from active participation in the management of the firm. Mr. Hanneford-Smith was well known to many engineers, however, as editor for many years of *Kempe's Engineer's Year-Book*. His father, the late Francis Smith, collaborated with H. R. Kempe in the establishment of the Year-Book in 1894. William Hanneford-Smith was appointed editor in 1907, a position which he retained, in addition to his work with B. T. Batsford, Ltd., until 1929, when *Kempe's Engineer's Year-Book* was acquired by Morgan Brothers (Publishers), Ltd., the proprietors of The Engineer. Our friendship with Mr. Hanneford-Smith was a long and at all times cordial one. We, in company with many others in engineering and publishing spheres, remember him with esteem.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

UNIFIED SCREW THREADS

Sir,—It would be interesting to know why it was considered necessary to produce a B.S.I. Standard for the unified thread. The potted history in B.S. 1580 : 1949 makes it quite clear that whatever the British representatives suggested at the various meetings was met with a blunt rejection. It would seem that in the later stages of discussion, the Americans must have realised their tolerances needed amendment and a thorough revision took place. The standard American thread with the revised tolerances was then suggested to our representatives on the basis of take it or leave it, but as a concession we could round off the root and crest of the threads. Assuming this supposition is correct, why could not a statement have been issued after agreement had been reached that :

"For armament purposes we would, in future, use the revised American National thread and that all spanners made to S.A.E. standards then existing would fit the nuts." Nothing more seems to have been needed and a lot of time, money and paper could have been saved. Apart from this, many people would have been saved from thinking an entirely new standard thread with different sized nuts had been introduced. In any case, the pre-war situation is unchanged, the unified thread is only a paper complication

of the situation as it confuses the issue by giving another name to an existing thread system. One cannot help being struck by the following extract from the 1953 S.A.E. Handbook, screw thread section : " The revised standard represents a rationalisation and refinement of previous American standards without affecting interchangeability. The thread form is unchanged, &c."

It was also noticed that the extra fine thread series, eight thread series, twelve thread series and sixteen thread series are included as " Unified and American standards," none of which are included in B.S. 1580, presumably being considered as special threads and, in addition, that the Americans are quite aware rounded crests and roots are required at times. From this one would conclude that the only persons to benefit from all the meetings were the compilers of the American standards. Granted, a standard thread is required for armament purposes, but for commercial use there does not appear to be any point in following American practice blindly. The Americans have no difficulty with any Whitworth form threading tool, as their pre-war tap and die production of all British threads must have been equal, if not greater than, that of the U.K. There is also the fact to face that if the Americans considered that any commercial article made in Great Britain was becoming interchangeable with their own products by reason of the screw threads, then an immediate change of thread in the American product would very likely be made.

Could an official statement be made as to whether we are supposed to scrap the finest screw thread system in the world in favour of a poor imitation of it which was introduced solely to be non-interchangeable with the Whitworth system. It is hard to believe that this is so, as it is understood that a further unified standard for pipe threads is being introduced, but this time using the Whitworth form. This being so, why issue another standard ? Surely B.S. 21 and B.S. 61 are sufficient. After ploughing through the large section on screw threads contained in the S.A.E. Handbook, it is a great relief to return to the clear, concise information given in the British Standards. Finally, for ordinary purposes, there is no reason why the two systems should not exist side by side. The British systems as a whole are more simple than the American and, what is more, the whole country is tooled up for them ; but, please, let us forget the name " unified " together with B.S. 1580 and call this system by its proper name—" The American National Thread."

BRYAN B. BATEMAN

Liverpool, May 3rd.

SCIENTISTS AND TECHNOLOGISTS IN INDUSTRY

SIR,—Mr. Kington's letter (your issue of April 9th) mentions the gulf which exists between Science and Industry and refers to the need for a new type of man, be he a scientist or an engineer, to bridge this gap. A great deal has recently been said on this vital subject, but it appears that little more than lip service is being paid by industry to the progressive principles propounded by its leaders. It is obvious that such a person must hold a senior position in order to make his influence felt ; however, a brief glance through your " Situations Vacant " columns will show that the essential qualifications for recruitment to the higher ranks of industry seem to be " under twenty-eight years of age " or " sales and production experience," while often " all senior posts are filled from within the organisation." It appears that at the moment industry does not require a person with a science degree, workshop training, a good knowledge of design and experience in co-operative research.

A RESEARCH ENGINEER

Harlow, Essex, April 18th.

Nodular Cast Iron

THE INSTITUTION OF MECHANICAL ENGINEERS

A GENERAL meeting of the Institution of Mechanical Engineers was held in London, in conjunction with the Automobile Division and the Applied Mechanics Group, on Friday, April 30th. At this meeting a paper, " Nodular Cast Iron : Its Present Position and Future Prospects as an Engineering Material, with Special Reference to its Suitability for Crankshafts," by Mr. S. B. Bailey, was presented and discussed.

DISCUSSION

Dr. H. T. Angus : We are all indebted to the author for having collected so much information from a wide range of sources which had been scattered previously and tended to be inaccessible, and for having brought it into the compass of one paper. The paper itself sets out to summarise the mechanical properties, the commercial uses and the economics of use of nodular cast iron, but the mode of presentation implies that the slow development in the use of nodular iron has been the result of failures, rather than the inherent caution, both in the foundry and engineering industries, which has delayed the large-scale application of a material whose properties were imperfectly known.

It is, after all, reasonable to expect, in any new process, that difficulties will arise, both in production and application, but I know of no evidence to confirm that engineering and research organisations have lost confidence in the material, and the number of cases of castings which have broken in transit or on first test must be so small as to bear comparison with similar failures in other conventional engineering materials. I, personally, think it is very unwise that such statements should go out in the *Proceedings* of this Institution, under the apparent ægis of the D.S.I.R.

The significant factor about nodular irons is not so much that the impact strength is substantially lower than that of the cast carbon steels, but that it is four to ten times as great as that of grey cast iron which, after all, has proved to be a structurally reliable material.

In comparing the material with traditional malleable iron and steel castings, it is unwise to draw conclusions as to its likely usefulness on the basis purely of price and mechanical properties. There are many cases, for example, in which steel castings are specified merely because grey iron was just not sufficiently resistant to shock for the purpose, and the section was too great for malleable iron. In cases like this, nodular iron has an obvious field, since it is free from many of the founding difficulties of cast steel, and has considerably improved machinability.

The author makes the interesting point that in his opinion torsional fatigue accounts for more crankshaft failures in service than bending fatigue. This may well be the case with steel shafts, but in cast iron shafts it is my impression that bending fatigue is the more usual form of failure, and, indeed, as the author has remarked, Table IV in Appendix 5 shows that the ratio of fatigue strength to tensile strength in reverse torsion is much higher in the case of flake graphite cast irons than in the wrought alloy steels.

The implication in a footnote, however, that for nodular cast iron it would be wise to assume that the notched torsional fatigue strength is not more than 15 per cent of its ultimate tensile strength would seem to err on the side of caution, as it brings the notched torsional fatigue strength down to that of an ordinary high-duty iron.

The author's comment that the engine must be designed around any cast iron crankshaft is undoubtedly correct, and these remarks will also apply equally with nodular iron as with high-duty grey cast iron. The author has made an important point in his comment that ductility is not, in general, a requirement for crankshafts of any kind. In by far the majority of cases the fatigue strength, both in bending and torsion, is of far greater importance than ductility.

Dr. A. B. Everest : I am afraid that I do not consider that the paper is a very fair one, and I think that it is likely to lead to a certain amount of misunderstanding.

The author has written his paper under the title " Nodular Cast Iron." For many years past the term " nodular " has been associated with the graphite form found in malleable cast iron. When the new iron, about which he writes, was first announced, the term " nodular " was applied initially on account of an apparent similarity to malleable as regards properties. The paper clearly shows that the graphite forms are, however, quite different, and it is for this reason that European metallurgists and foundrymen associated with the development of this new material have adopted the more accurately descriptive name " spheroidal graphite cast iron " (S.G. iron for short).

The author focuses attention on crankshafts—an application for which S.G. iron has already been used with outstanding success in service. The audience, however, should not overlook the fact that S.G. iron is being adopted in almost all fields where castings are used, and it has many other applications of equal or even greater importance. I would particularly mention gears, where experience has shown that S.G. iron gives long life under arduous conditions.

The author makes passing reference to S.G. iron for high-temperature service, and refers to the lack of data on strength under these conditions. In this field, S.G. iron is already established as offering greatly improved heat resistance with greater stability and less growth than is experienced with ordinary iron. Concerning high-temperature strength, some creep data have already been published and indicate that from this point of view S.G. iron is equal to or even better than plain carbon steel up to a temperature of 450 deg. Cent., and has useful creep strength up to even 600 deg. Cent.

The author suggests that S.G. iron castings are not weldable. It is true that initially difficulty was experienced with welding, but the development of suitable welding rods and techniques is well advanced.

In my opinion, this paper is far from fair to S.G. iron. It is generally admitted to be of great promise and is being taken up enthusiastically.

Dr. J. G. Pearce : All branches of engineering make use of iron castings, and I think engineers will agree that the remarkable results achieved from nodular cast irons indicate a bright future for this virtually new engineering material.

This future is largely tied up with the development and production of nodular iron by the methods now established. Although intensive efforts have been made in laboratories in many industrial countries, no practicable commercial alternative to the cerium-magnesium process is at present in sight.

Great efforts have been made in this country and in the U.S.A. to accomplish nodulisation by the use of calcium, but except in special circumstances and with the aid of temperatures not normally achieved in a foundry, it is not at present a practicable commercial process.

We do not yet know the precise mechanism of the process, nor the exact function of the nodulising agents, but the B.C.I.R.A. recognises both the limitations of the use of cerium alone and the value of the part played by magnesium. Unless raw material supply conditions are exceptional, it recommends the double treatment, cerium-magnesium, method to ensure freedom from processing difficulties and has no doubt that this treatment ensures complete nodulisation if a recommended procedure is faithfully followed. Many of the early difficulties referred to by the author arose from the inhibition of the action of magnesium due to the presence of small quantities of trace elements in raw materials, pig iron and scrap. The establishment by Morrogh in the B.C.I.R.A. laboratories of the safe limits for these elements and that cerium is an effective antidote to their harmful effects, disposed in the main of those early difficulties.

Since any cast iron containing graphite can be nodulised, and since in the wide variety of modern cast irons practically any metallurgical structure can be made to predominate to suit specified service requirements, care should be taken in comparisons of nodular with flake graphite irons to compare like structures with like. Furthermore, in considering alloyed irons, the nodulising additions are not regarded as alloying in the usual sense, although when nickel and/or copper are present as a vehicle for the introduction of magnesium they have their usual alloying effects, albeit not added for the specific purpose of producing an alloyed cast iron.

Comparatively little work has so far been published on the alloyed nodular irons, but austenitic, austenitic-martensitic and acicular irons in this form are in active manufacture.

Mr. H. Morrogh : This paper contains many references to the ductility of nodular cast iron, and incidentally demonstrates the considerable confusion which exists in defining this property. As far as cast iron is concerned, the unique property of this material is its ductility, and yet, after reading this paper, one is left with the impression that, after all, it is not quite such a ductile material as some would claim.

The graphite in nodular cast irons has a definite beneficial effect in minimising the tendency to brittle failure. The more graphite you have present, the lower is the impact transition temperature. Nodular cast irons of an appropriate correct composition in the ferritic condition can have V-notch impact transition temperatures of −50 deg. Cent., and, by adjusting the composition, even as low as −100 deg. Cent. Thus, nodular cast irons, in proneness to develop brittle fracture, are superior to very many steels, and it may be argued, therefore, that they are more ductile than steels.

The ability of nodular cast iron to withstand shock loads without rupture appears to rival that of many steels.

Mr. M. M. Hallett : We foundrymen look rather askance at some of the inferences drawn by the author. The paragraph which strikes us with particular chill, of course, is the one in which he refers to continued failures and the loss of confidence by engineering firms and research organisations. I do not want to labour this point, but I should like to make three simple, unequivocal statements.

On checking through our own production records over the last five years—which now amount to several hundred heats—I have found only three or four heats which did not show an entirely satisfactory spheroidal graphite structure. For each of those three or four heats there was a perfectly simple, rational and straightforward explanation. To make the matter clear I should add that those heats were all made using an addition of nickel-magnesium alloy on an approved pig iron.

The second statement is that during the same period I can recollect no case of a casting having been returned by a customer as showing unsatisfactory spheroidal graphite.

Thirdly—turning now to the crankshaft illustrated by the author—approximately 20,000 of those crankshafts have been made and delivered. To date there has not been one single case of failure in service.

The author has devoted most of the paper to a description of spheroidal graphite iron in the as-cast and the annealed conditions. I think I should make the point that it can also be heat-treated in a number of other ways, by oil quenching and tempering, in exactly the same way as an alloy steel. In fact, those crankshafts were all heat-treated, not to give ductility, but to give another desirable combination of properties.

The author has referred in his remarks on the annealing treatment to the material usually being annealed for four hours at 900 deg. Cent. That is an extraordinary treatment which would certainly not necessarily produce a ferritic background. The ferritic background will be formed at much lower temperatures. If you cool slowly from 900 deg. Cent. then you will form ferrite, but normally it is treated at a much lower temperature.

Mr. R. J. Love : I should point out that from our crankshaft experiments at the Motor Industry Research Association we concluded that simple notched or unnotched fatigue specimens did not necessarily give an indication of the relative merits of cast materials, and to obtain a reasonable comparison of materials tests on full-size crankshafts were necessary.

The author has stated the need for a comparison of fatigue strengths of forged and cast crankshafts of the same design. At M.I.R.A. we have in fact had the opportunity on two occasions to make such a direct comparison, using production crankshafts of automobile size. In the two investigations, using a flake graphite iron of about 26 tons per square inch tensile strength, and a steel of 55 to 65 tons per square inch tensile strength, the high-duty flake graphite iron crankshafts had about half the bending fatigue strengths of the forged crankshafts.

This would appear to place the cast crankshaft in an unfavourable light, but, in my opinion, much can be done to improve the strength of the cast crankshaft in relation to that of the conventional forged one. Furthermore, I would make the point that to say that a cast shaft is weaker than a forged shaft in laboratory tests is not to say that the cast shaft is necessarily inadequate for service operation.

The use of cast shafts in a wide range of engines is now well established. In view of the excellent results which have been obtained with flake graphite iron in many engines—and this includes its use in automobile engines—there is no doubt that in respect of strength the nodular iron crankshaft, with its somewhat greater bending fatigue strength and greater torsional stiffness, will be at least equally successful.

Mr. S. B. Bailey (in reply) : The opinions expressed in the paper are entirely my own, and I do not think they should be connected at all with any official views.

Dr. Everest said that he did not agree with my introductory remarks when I said that the ultimate tensile strength of nodular cast iron and its ductility are about four times that of ordinary grey iron. I was comparing an as-cast nodular iron of 40 tons tensile strength with a typical ordinary grey cast iron of 10 tons ultimate tensile strength, and I do not think I am far wrong in saying that the elongation to fracture of those two materials would be 2 per cent and ½ per cent.

I had not overlooked the fact that some creep data had been published. It was not available when the paper was written ; it has since become available, and I will include it in my written reply to the discussion.

I agree that there is a very wide field for research into alloyed nodular cast irons. I would merely point out that my alloyed steels in no case contained more than 3½ per cent of nickel and some of the nodular irons on that curve contain an equal amount of nickel. I call them alloyed nodular irons.

I was very pleased to hear of the excellent results Mr. Hallett has had with his 20,000 crankshafts, without a single failure ; but I would very much like to know what the stresses were in those crankshafts. I would also point out that the firm which used to use these nodular cast iron crankshafts has since reverted to a steel shaft, and I am told that has been done because it is cheaper.

Books Received

Modulation Theory. By H. S. Black. London : Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 65s.

Automotive Mechanics. By J. Heitner. London : Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 45s.

Beam Formulas. By A. Kleinlogel. London : Crosby Lockwood and Son, Ltd., 39, Thurloe Street, S.W.7. Price 40s.

The Home Workshop. By W. R. Wellman. London : Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 27s.

Flow and Fan. By C. H. Berry. New York : The Industrial Press, 148, Lafayette Street, New York, 13. Price 34s.

Materials and Processes. Second edition. By J. F. Young. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 68s.

Model Analysis of Structures. By T. M. Charlton. London : E. and F. N. Spon, Ltd., 15, Bedford Street, Strand, W.C.2. Price 21s.

Non-Ferrous Heavy Metal Fabrication in the U.S.A. Published by the Organisation for European Economic Co-operation, 2, Rue André-Pascal, Paris, 16e. Price 16s.

Newnes Engineer's Reference Book. Sixth edition. Edited by F. J. Camm. London : George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 70s.

The Electromagnetic Field in its Engineering Aspects. By G. W. Carter. London : Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 35s.

Manual for Plastic Welding. Vol. II : Polyethylene. By G. Haim and J. A. Neumann. London : Crosby Lockwood and Son, Ltd., 39, Thurloe Street, S.W.7. Price 30s.

Mechanical Testing of Metallic Materials. Third edition. By R. A. Beaumont. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 25s.

Optical Workshop Principles. By Charles Déyé, English translation by T. L. Tippell. Second English edition. London : Hilger and Watts, Ltd., 98, St. Pancras Way, N.W.1. Price 42s.

Oil in the Middle East. By S. H. Longrigg. Published for the Royal Institute of National Affairs. London : Oxford University Press, Amen House, Warwick Square, E.C.4. Price 25s.

Notes and Nomographs for the Design of Flat, Rectangular Plates under Normal Pressure. By G. D. Mouat. Published by The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey. Price 3s. to non-members. Available to members of the Association at 1s. 6d.

Folding and Sliding Doors for an Aircraft Hangar

The maintenance base under construction for B.O.A.C. at London Airport has four large hangar openings which are each to be closed by a pair of folding and sliding doors, covering 300ft by 46ft. The doors are of aluminium alloy construction and embody several advances over previous practice.

WE were recently invited to see the first of four similar pairs of folding and sliding doors which are being constructed for the maintenance base of British Overseas Airways Corporation at London Airport. The maintenance base is a large reinforced concrete building, consisting principally of four large hangars, the construction of which is now well advanced. Each hangar has an opening of 300ft span, formed by two massive reinforced concrete cantilevers carrying a suspended span between them. Thus a door opening 300ft long by 46ft in height is provided for each hangar, and is in each case to be closed by a pair of folding and sliding doors of aluminium construction. The design of the doors is considered to incorporate several advances over previous practice, and the pair of doors which has already been installed has, we are informed, so far functioned smoothly and effectively.

The basic structure of each door comprises a number of vertical load-bearing members—the mullions—which run on rollers and guide tracks at the top and bottom of the door opening. A pair of leaves is hinged between each pair of mullions, the leaves being hinged to each other as well, and carried by the mullions, so that they fold together as the door opens. The general construction will be apparent from the photograph reproduced above, and from the various details shown in the drawings.

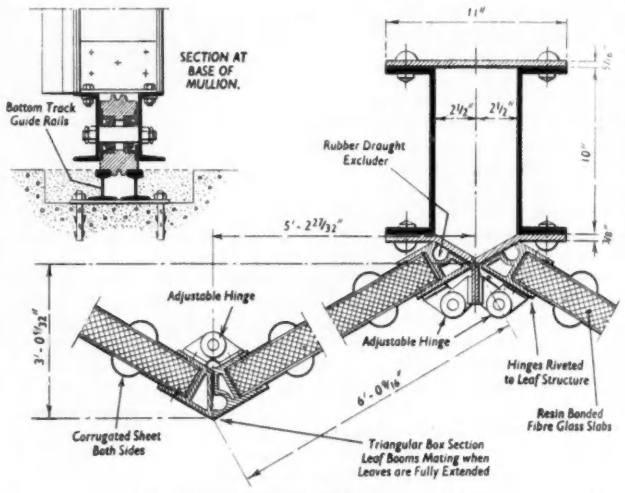
The structural stability of the door is primarily dependent upon each of the mullions remaining accurately vertical at all times. A simple system of cables and pulleys and parallel link motions meets this requirement. The end mullions of each door are hollow, and the ropes and pulleys are accommodated inside them ; the diagram herewith illustrates the control cables of one end mullion. One cable is anchored at the top corner of the door opening, passes horizontally along the top of the opening and over a frictionless pulley at the top of the mullion, and then over a second pulley at the bottom of the mullion and along the bottom of the opening to its anchorage in the opposite bottom corner. The second cable follows a similar path between the other two corners of the door. It will be seen that the mullion can move along the track, practically without frictional resistance from the cables, but it cannot be moved out of the vertical without causing an extension in length of one of the cables. This simple parallel motion was, we understand, used in the construction of a lifting bridge about a hundred years ago, but has had very few other applications in engineering practice. Such a cable control is used for the mullion at each end of the door. Distortion of the door by " fanning " of the intermediate mullions is avoided by a simple linkage system between each pair of mullions, which ensures parallel motion and, hence, verticality of every mullion. The linkage is clearly shown in our first illustration ; there is a folding traction bar at the lower end of each linkage, its purpose being to transmit the pull of the driving motor directly from one mullion to the next when the gate is being opened and the leaves are fully extended.

The method of opening and closing the door is noted in the diagram. The control cables move in opposite directions up and down the mullions as it moves across the opening. Therefore, by taking several turns of each cable round additional pulleys placed inside the mullion, and driving these pulleys, the door may be opened or closed. Thus, three turns of each cable are taken in opposite directions round the flanges of a twin driving pulley, which incorporates a differential gear. Normally, the two driving pulleys rotate solidly, but if the cables creep along the groove round the pulleys, relative motion occurs between the two pulleys. This motion is taken up by the differential gear, which thus forms an important element in the design ; without it, excessive tensions would build up in the cables which would need frequent adjustment.

The doors are built almost entirely of aluminium alloy ; the top and bottom runners are of mild steel, as are the links and various other fittings. The total weight of aluminium in the four pairs of doors which will ultimately be installed will be 195 tons. For the various sections Naval SI S.W.P. (that is, B.S. 1476 HE 10) was used, for the sheeting BA 60 (B.S. 1470 : NS3), and for rivets B.S. 1473 : NR 6–M.

Door of B.O.A.C. Maintenance Base at London Airport

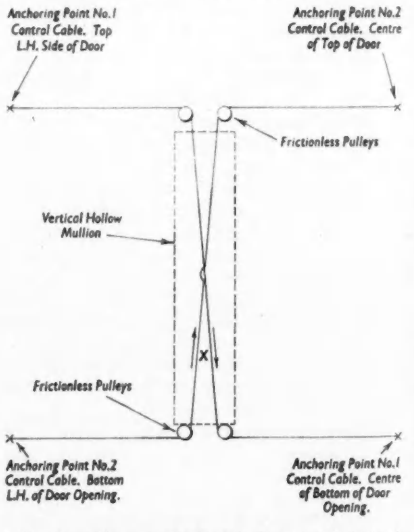
The mullions are subjected to appreciable twisting moments from the asymmetrical loading and the angular accelerations during opening and closure of the folding leaves ; they are thus of hollow box section, which gives a good torsional rigidity. They run on substantially frictionless rollers at the top and bottom guide paths. The leaf frames consist of main vertical members of hollow triangular box section, which mate together when the doors are closed, and of H-shaped cross members and diagonal bracing. Each leaf is 46ft high and 6ft wide. The frames are completed by corrugated aluminium sheeting on each side, filled in with fibre glass for thermal insulation. The leaves were designed for a wind pressure of 25 lb per square foot over the whole of the exposed door surface. Further details of the draught-excluding seals, specially extruded sections and so on, will be apparent from the accompanying detail drawings, which also show the base and head trolleys of a power mullion and a section at the base of an ordinary mullion. Wicket doors and windows are incorporated in the lower part of the leaves of each door. The lower track is formed of twin 40 lb per yard steel rails and the upper one of two 5in by 28 lb per foot R.S.J.'s placed horizontally and faced with steel plate. The control cables have a breaking strength of 5·8 tons and are 1¼in in circumference.


SECTION AT BASE OF MULLION.
Bottom Track Guide Rails
Rubber Draught Excluder
Adjustable Hinge
Adjustable Hinge
Hinges Riveted to Leaf Structure
Resin Bonded Fibre Glass Slabs
Corrugated Sheet Both Sides
Triangular Box Section Leaf Booms Mating when Leaves are Fully Extended

Constructional Details of Mullion and Leaf

Operation

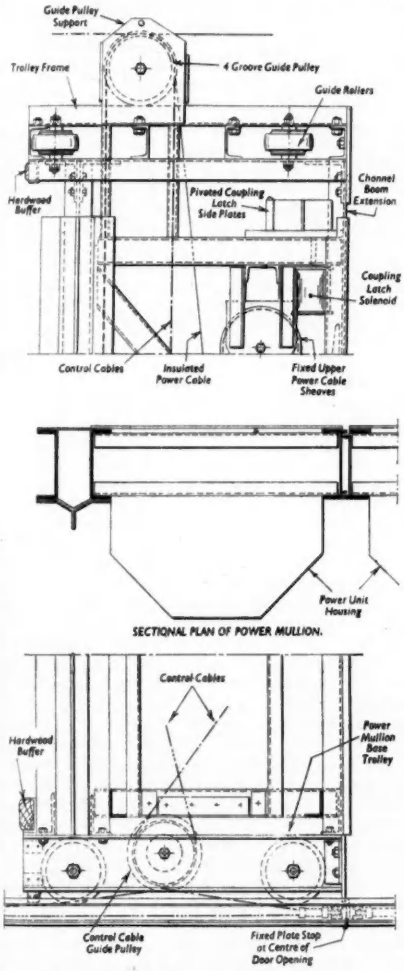
The power transmission unit of each door is a self-contained assembly in its own frame, which


Anchoring Point No.1 Control Cable. Top L.H. Side of Door
Anchoring Point No.2 Control Cable. Centre of Top of Door
Frictionless Pulleys
Vertical Hollow Mullion
X
Frictionless Pulleys
Anchoring Point No.2 Control Cable. Bottom L.H. of Door Opening.
Anchoring Point No.1 Control Cable. Centre of Bottom of Door Opening.

When the mullion moves horizontally the two cables inside the mullion, as at point *X*, move with equal speed in opposite directions as shown by the arrows. By taking several turns of each cable in opposite direction round the flanges of two twin driving pulleys respectively, the driving pulleys being rotated through a differential gear by the power unit, the mullion is hauled across the door opening.

Diagram of Power Mullion Cables

is bolted on to a housing on the lower part of the power mullion. It comprises a motor of 4/5 h.p., operating on a three-phase power supply at 1440 r.p.m.; an automatic spring-adjusted centrifugal clutch set to slip at a given maximum torque, thus preventing overloading of the motor; an electro-mechanical brake; a "Heliocentric" 80 : 1 reduction gear, and the differential driving pulley mentioned earlier. These differential driving pulleys form the two halves of an oil-tight casing driven by an inner driving plate keyed to the shaft through bevel gear wheels. If the mullion should be slightly out of the vertical when the doors are closed together, the differential pulleys also allow the mullion to be brought hard against the upper and lower fixed stops at the centre, independently of one another, so that the door may be locked.



Power Mullion Base and Head Trolleys

The driving gear opens the doors at a rate of 100ft per minute. There is also an emergency hand operating gear.

The electricity supply cable for the operating motor is an insulated cable, carried on guide pulleys on the mullion heads, across the door and led directly down through the interior of the power mullion. When the power mullion traverses across the door opening the slack of cable is taken by a pair of sheaves carrying light aluminium pulleys on anti-friction bearings. The upper sheave is fixed at the top of the mullion; the lower heavy sheave traverses vertically between guides through the height of the space in the interior of the mullion. Three turns of cable are taken round the two sheaves, the vertical movement of the lower sheave being thus one-sixth of the total movement of the power mullion, while the weight of the lower sheave impresses a tension of about 10 lb on the power cable. The lower sheave draws in and pays out the slack automatically by virtue of its own weight.

Contact and limit switches are provided to make it impossible to start the motor in either direction when the wicket doors are open or if the main doors are locked at the centre. Limit switches break the motor circuit near the limit of travel of the door in both directions, and opening and closure is completed by an "inching" control. The "opening" limit switch is arranged to stop the motion of the door at the entrance to the pylon at the side of the door opening. The folded half-door can only be housed from a second operating position in which it is possible to see that the space inside the pylon is clear of obstruction.

Fabrication of the Doors

The fabrication of the doors called for a complete shop layout and a rather different approach than that normally associated with an aluminium structure. Each leaf and pillar carry five sets of pintle hinges in their length, and whilst a small degree of adjustment was available in the vertical position, it was imperative that true alignment should be maintained between pillar and leaf.

The pillars were assembled on the tack bolting principle, and every hole was reamed and slightly countersunk before riveting. To ensure straightness stitch riveting was employed on the pillars and finally a riveting sequence was evolved giving minimum distortion. Squeeze riveting was employed, the formed head being of the North American cone type. A roller conveyor was laid down at the squeeze riveting machine and by keeping the machine stationary and moving the pillars on the conveyor riveting times were kept to a minimum. The rivets were of ¾in diameter, and were clenched hot. Rivet heating was carried out in an electric muffle furnace with automatic temperature control. The furnace was stationed as near as possible to the workpiece and sand trays were employed to maintain temperature whilst the rivets were transported from the furnace to the job.

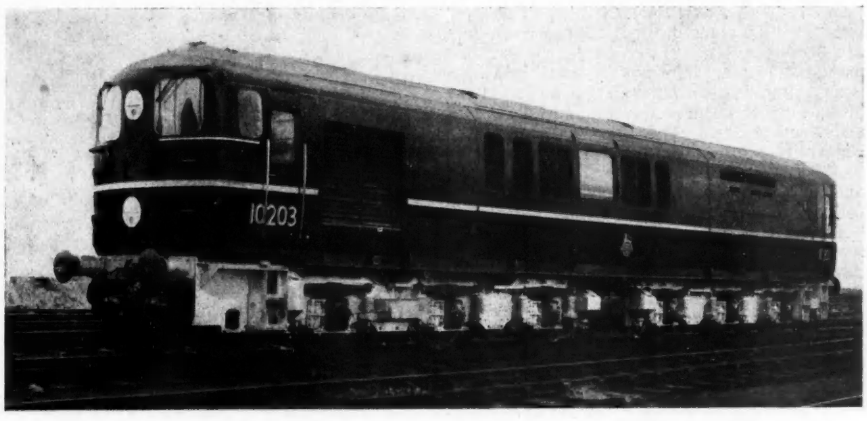
The sheeting of the leaves was fixed on one side with ¼in diameter solid rivets, the other side being inaccessible from the point of view of backing up for rivets, was secured by "pop" riveting. The framework of the leaf was first jig assembled to ensure squareness, jig drilled in special jigs for hinge positions, and sheeted on one side and riveted. The hinges were then fixed and the "Fibreglass" insulation was inserted before final sheeting, inspection and storage ready for dispatch. The layout was for a production run and commenced from marking and cutting at one end of the shop to the completed leaf being ready for dispatch at the other end. To ensure accurate position of the hinges on the pillars and leaves, a series of brick and concrete piers were set up, into which were set fixed bushed drilling jigs. The jigs themselves were aligned by instrument and checked at intervals for movement. By using a joint set up for pillars and leaves, a high degree of accuracy was maintained throughout.

The doors described in this article were designed for the Ministry of Transport and Civil Aviation by Mr. J. E. Temple, 9A, Seymour Walk, London, S.W.10. The contractor responsible for their construction and erection was Head, Wrightson Aluminium, Ltd., Thornaby-on-Tees. The aluminium alloy sections and sheets were supplied by the Northern Aluminium Company, Ltd., and the British Aluminium Company, Ltd., respectively, and the aluminium rivets by J. Stone and Co. (Deptford), Ltd. The power unit assemblies were supplied by Pickerings, Ltd., and the top and bottom track steelwork and traction units by H. Pickup, Ltd. The B.O.A.C. maintenance base is being built by W. and C. French, Ltd., to the designs of Sir Owen Williams and Partners.

2000 h.p. Diesel-Electric Main Line Locomotive for the Southern Region

THE third main line mixed traffic diesel-electric locomotive for the Southern Region of British Railways has just been completed at the Brighton works. This new 1 C_0–C_0 1 locomotive, of 2000 h.p., as can been from the illustration on this page, has similar lines to the earlier 1750 h.p. locomotives which were described in detail in our issue of February 9, 1951. It weighs 132·8 tons, of which 109·5 tons are adhesive with a maximum axle load of 18·6 tons. The leading dimensions are identical with the two 1750 h.p. locomotives, but the starting tractive effort is 50,000 lb and the continuous rating 30,000 lb at 19·5 m.p.h. The maximum speed is 90 m.p.h. and the wheel diameters are: driving 3ft 7in and carrying 3ft 1in, as in the case of the earlier locomotives. The six driving axles are each driven by a six-pole, nose-suspended motor through single reduction straight spur gearing with a ratio of 19 : 61.

The underframe consists of two heavy I-section centre longitudinals, and two outer channels, joined by suitable cross bracing to form a rigid structure, the attachment of the various members being principally by welding. Four lifting lugs are provided along each side, and the decking is of all-welded steel plate. The body, of riveted and welded construction with a driving cab at each end, is divided into compartments for radiators, engine, electrical equipment and boiler. The two main fuel tanks are carried adjacent to the engine on either side of a central gangway. Water storage is provided in two side tanks alongside the electrical equipment compartment and one auxiliary tank formed in the centre portion of the underframe between



2000 H.P. Mixed Traffic Diesel-Electric Locomotive for the Southern Region

the two main longitudinals. The bogies and braking equipment are almost identical with those on the two other locomotives, as are the driving cabs and the controls.

The diesel engine is the most recent design of English Electric sixteen-cylinder, vee-form, four-stroke, pressure-charged "16SVT/II" engine of the 10in by 12in "RK" and "VT" series. This engine has a continuous traction rating of 2000 b.h.p. at 850 r.p.m., and the input to the main generator, after allowing for all auxiliaries, is estimated to be 1880 b.h.p. The corresponding b.m.e.p. is 123 lb per square inch and the piston speed 1700ft per minute. In this application the engine weight is 46,510 lb or 20·2 lb per brake horsepower. The specific weight of the power unit complete is 28 lb per brake horsepower.

The engine has four Napier turbo-superchargers and the cylinder heads have two exhaust and two air valves. Push rods and rocker gear of conventional pattern are enclosed in individual aluminium casing covers for each head. The variable-speed hydraulic servo governor is driven through bevel gears from one camshaft, and is arranged for remote operation from the master controller by compressed air. It is so designed as to give full torque control from 450 to 850 r.p.m. Idling speed is set at 470 r.p.m.

The ten-pole main generator is directly coupled to the engine and the outer end of its shaft is supported on a self-aligning roller bearing. The shaft is extended to carry the armature of the auxiliary generator. At 850 r.p.m. the continuous rated current of the generator is 1750A and the maximum voltage is 965V.

The overhung auxiliary generator has its frame bolted directly to the main generator bearing endplates. This auxiliary generator has no bearings and is an eight-pole d.c. shunt wound machine rated at 48kW, 135V, 356A at 850 r.p.m. It supplies current to all auxiliaries, except the radiator fan motor, and current for charging the sixty-cell, 236Ah lead-acid battery.

The six traction motors are of six-pole series wound design, force ventilated, three motors being ventilated from each of two motor-driven blowers. The motors are permanently connected in series-parallel there being three groups of two in series; each group is fed through a separate motor contactor. There are three stages of field weakening by non-inductive shunt and the minimum field is 25 per cent.

Control equipment consists of electro-pneumatic and electromagnetic unit and group switches, the main power contactors and reverser being of electro-pneumatic design. The engine throttle gear is pneumatically operated from the master controllers, giving infinitely variable control. This control permits the utilisation at all speeds of the full power output available from the engine, allowing it to function at all fractional loads, preventing overloading of the engine and automatically controlling the field weakening of the traction motors at the correct instant. The load-regulating equipment is basically the same in operation as that installed in the other locomotives, except that it operates over the full engine speed range instead of at the top engine speed only.

Flexible Element Fire Detector

LAST week we were invited to a demonstration of the Graviner "Firewire" fire detector, which enjoys some important advantages over existing detection equipment in aircraft. It is now in quantity production by the Graviner Manufacturing Company, Ltd., following five years' development work in collaboration with the R.A.E. and Rolls-Royce, Ltd.

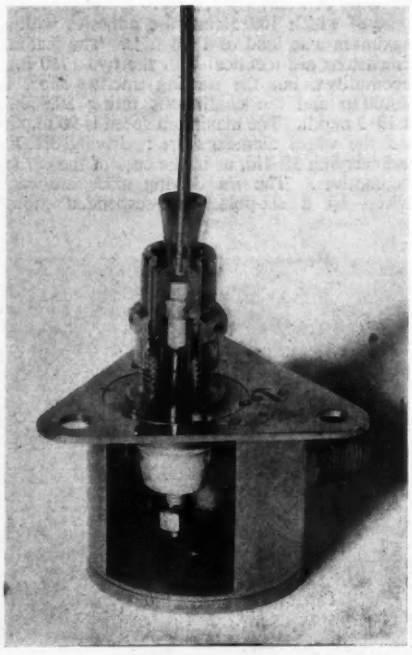
Normally detection of a fire in an engine installation has depended on the functioning of independent detectors placed strategically in the engine bay. The number of detectors is limited by considerations of weight and a fire can establish itself before embracing one of the detectors. On the other hand, because of the temperature differential around the engine — particularly a gas turbine — the occurrence of false warnings cannot be eliminated. This latter contingency can itself lead to the abandonment of the aircraft in flight. The higher temperature associated with the gas turbine also led to more rapid deterioration of the wiring between detectors and consequently increased the vulnerability of the system to short circuits and false warnings. There is also the circumstance that many fires are preceded by mechanical failure in the engine, which in the past has tended to wreck the wiring connecting the unit detectors before they could function. It is also possible for the mechanical temperature setting of these units to become maladjusted.

In all these respects the superiority of the new system will be realised, for it consists essentially of a flexible element sensitive to temperature over its whole length. The other components in a typical circuit are a coupling unit, twin bulkhead fittings, one of which is shown in our illustration, and a relay box. The response time of the element is less than four seconds when subjected to the R.A.E. standard flame (1100 deg. Cent.) and is not impaired when exposed to this flame for the stipulated period of six minutes.

It operates on a.c. current and has been manufactured to suit both the 26V and 115V ranges. Normal standby input current is 11mA on 115V supply. In order to give unimpaired monitoring of the fire zone, even in the event of a fractured element, the element is connected at both ends, forming a ring. This method of connection enables a continuity check of the element to be made from a relay box location by the visual or audible warning system. No electrical wiring is used in the fire zone.

The sensing element is a stainless steel capillary containing a central wire electrode separated from the walls of the capillary by a temperature-sensitive material completely filling the capillary. The electrical resistance of the filling material decreases with increase of temperature and rises as the temperature falls. When the temperature of the element reaches a critical value the current flow in the circuit becomes sufficient to operate the relay in the fire warning circuit. When the temperature of the element drops to the resetting value the current flow in the circuit is insufficient to hold in the relay.

Flange-mounted adaptor units accept the coaxial end fittings of the sensing element on the fire zone side of the bulkhead, and on the other side provide 4BA terminals for electrical connection. Earthed terminal pins are provided for return earth leads to the relay unit, if preferred to the air-frame earth return system. Protective covers with AGS cable entries are provided.



Hermetically Sealed Bulkhead Fire Detector Fitting

The relay unit is a hermetically sealed box containing a transformer, full-wave rectifier, relay and hold-on toggle type test switch. Cable connection is by three Plessey Mark IV panel units, the inserts for which are so orientated that the three cable units are not interchangeable.

The minimum bend radius of the sensing element is 2in. The bulkhead fittings are mounted through the fire wall or other appropriate structures in the fire zone and the sensing element routed through all regions where flame is likely to be met and not too close to parts of the installation liable to reach temperatures in excess of its resetting temperature.

The greatest single problem during development was to discover a suitable temperature-sensitive material. Its solution was provided by the R.A.E., Farnborough.

Construction and Testing.—The method of filling the capillary and ensuring coaxial relationship of the central wire within it has not been disclosed, but it is stated that extreme care comparable with surgical practice has to be adopted throughout the operation. The smallest traces of natural grease on the temperature-sensitive material result in unacceptable insulation resistance characteristics in the finished product.

A few inches of the filled capillary are removed from each end of every length in order that adhesion and homogeneity of filling material, spacers and central wire may be examined. Samples are prepared by immersing them in a concentrated hydrochloric-nitric acid mixture until the stainless steel sheath has been dissolved away. The results of microscopic examination are then logged against the serial number of the particular length which is then checked for insulation resistance, coiled flat and X-rayed to ensure that there is no displacement of the central wire at any point. The X-ray negative is similarly filed with the serially numbered ends.

A temperature/current curve for each coiled element is plotted while it is raised from 20 deg. to 350 deg. Cent. in a closely controlled air circulating furnace. This proves the consistency of the filling material from batch to batch and serves incidentally to remove any moisture that may have entered the open ends of the capillary.

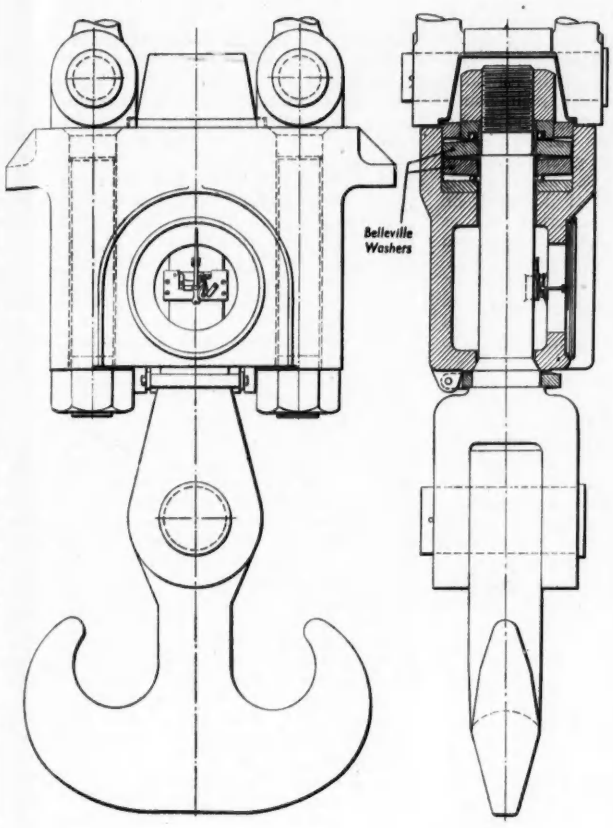
The object in providing the particular design of end fittings is to permit electrical and mechanical connection from the ends of the length to adjacent lengths or bulkhead fittings and to provide double hermetical sealing.

It is essential to provide hermetical sealing and high insulation resistance at the joint between the ends of the capillary and the insulated plug pins. With the help of Lodge Plugs, Ltd., a special design of Sintox metal bonded bush was evolved and this is encased in a stainless steel housing as shown. The central wire is silver soldered to the end of the hollow plug pin, and since at this stage it is not possible to pressure test the resulting joint, the completely assembled, but open-ended, length of detector is totally immersed in water and pressure cycled for three hours between sea level and 45,000ft altitude and checked for insulation resistance. If the entire assembly is not absolutely "bubble-tight" a large drop in insulation resistance is recorded on subsequent checking with an electronic test meter.

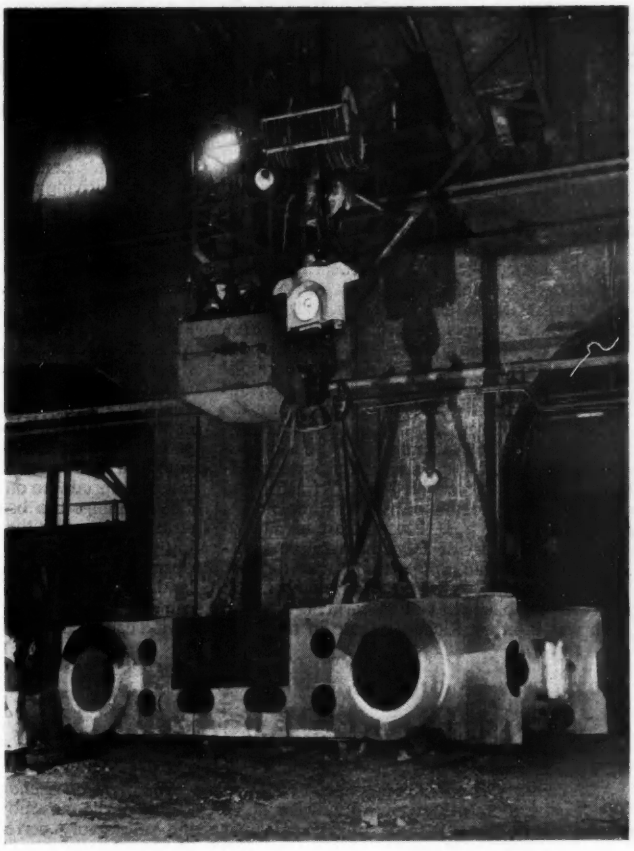
Every length is subjected to the standard flame (1100 deg. Cent.) to establish its response time.

The system is a very much lighter one than others in current use, notwithstanding its greater coverage, and, having no valve amplification, it is more resistant to shock and vibration. It can be short-circuited only by flattening a section of the element to paper thickness.

ROAD ACCIDENTS.—The Ministry of Transport has stated that casualties on the roads of Great Britain in March totalled 15,935. This was 95 more than in March of last year and included 367 killed, an increase of 10. The seriously injured numbered 3788, a decrease of 192; the number of slightly injured rose by 277 to 11,780. The Ministry says that a review of the first quarter of the year shows that 1016 persons were killed on the roads and 42,333 injured. Compared with the same period last year there was a reduction of 402 in the total and of 75 in the deaths. This improvement, it is suggested, was probably due in the main to widespread snow and frost at the beginning of the year, which reduced the amount of traffic on the roads.



General Arrangement of 200-Ton Crane Weighing Machine



Crane Weighing Machine in Operation

200-Ton Crane Weighing Machine

AN impressive exhibit upon the stand of George Salter and Co., Ltd., of West Bromwich, at the British Industries Fair is a crane weigher of 200 tons capacity, which the firm has constructed for the English Steel Corporation, Ltd. This spring balance is stated to have the largest capacity of any such device yet built, and it weighs some 6 tons. In its normal vertical weighing position it is 12ft high from the base of its rams' horn hook to the top of the two shackles by which it is suspended from a crane. In tests carried out at Lloyd's Proving House at Netherton the weigher was subjected to a 50 per cent overload.

The general design of the crane weigher can be seen in the drawing reproduced herewith. The spring resistant is unusual, in that two Belleville washers are used, opposed to each other as concave surfaces. The middle piece passes through the centre of each washer and is held by a nut at its top end. Attached to the bottom end of the middle piece is the actual load hook, the arrangement being such that when a load is applied both the hook and middle piece are drawn down to compress the washers together against the top of the case. It is interesting to note that the actual movement of the load is never more than $\frac{1}{8}$in even under full load. The movement under load is converted by a quadrant and pinion into the rotary movement of a pointer round the load indicating dial. The dial is marked in 1-ton subdivisions up to 200 tons.

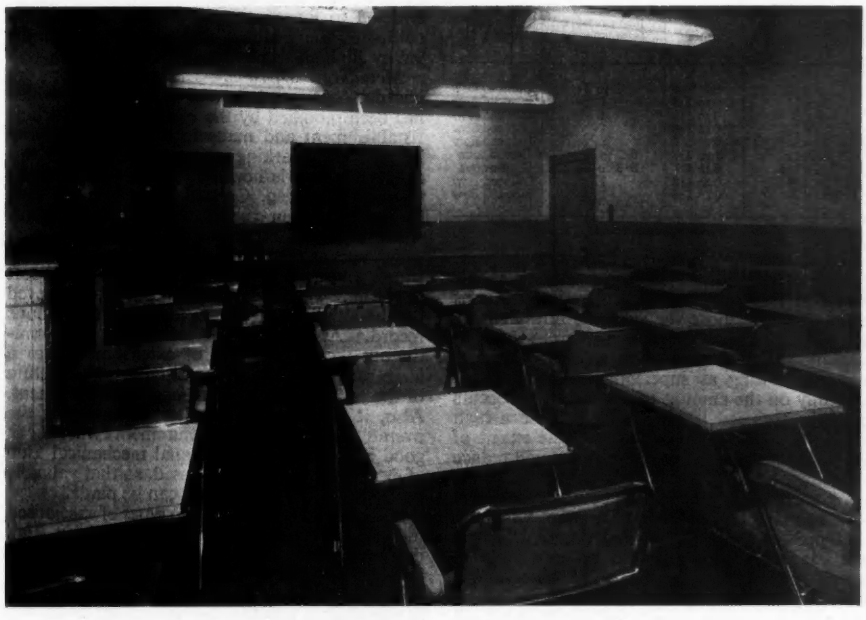
After the crane weigher had passed its overload tests it was taken to the University of Birmingham's Department of Civil Engineering for calibration. On the Department's 300-ton tensile testing machine a full load of just over 200 tons was applied, after which calibration of the dial was carried out, with the load readings on the steelyard of the testing machine being marked on the dial at increments of 10 tons. Twelve turns of 20 tons increments were made and checked and counter checked before the machine was finally passed by an inspector of weights and measures.

The crane weigher will be used to weigh large castings at the English Steel Corporation's Sheffield works, and in the photograph we reproduce it can be seen handling a 160-ton casting for a large press.

Mechanised Farming Centre in Essex

ON Tuesday, May 4th, a mechanised farming centre, which has been established by Ford Motor Company, Ltd., at Boreham, Essex, was officially opened by Major-General Sir Harold Wernher, chairman of the governing body of the National Institute of Agricultural Engineering. The centre houses a training school at which instruction in farm practice is to be combined with training in the economic application of modern machinery. Mr. E. B. Black, M.I.B.A.E., is the principal at the centre, and Mr. E. J. Bullock, M.I.B.A.E., director of studies.

The courses which it is intended to run at the centre are in two categories. The first caters for the staffs of the Ford Motor Company, Ltd., and its agents in this country and overseas. In this category, emphasis will be given to modern business methods in the agricultural engineering industry. Each course will include consideration of administrative and commercial



One of the Lecture Rooms at Boreham House

problems and also practical field instruction, the latter occupying about 30 per cent of the time. Courses of this nature will last for five days for those working in the British Isles and up to ten days for those coming from overseas. The second category is designed for tractor owners and those interested in the development of mechanised agriculture in all parts of the world. So far as possible, it will be arranged that each class in these courses comprises those concerned with similar geographical conditions. These courses, which will also last for five or ten days, will be open to overseas government officers, National Agricultural Advisory Service machinery advisers, the staffs of the Food and Agriculture Organisation and similar bodies, and students of agricultural colleges on vacation. In addition, there are to be shorter courses, lasting up to three days, for members of the National Farmers' Union, Young Farmers' Clubs, and various trade delegations. Provision is made in the courses for as comprehensive a survey as possible of mechanised farming. There is instruction in the operation, maintenance and performance of the "Fordson Major" tractor and in the correct application of the many implements now associated with it. Students are also taken to the firm's factory at Dagenham to see something of the manufacturing methods used there.

Boreham House, at which this training centre has been established, is a Georgian mansion which was built by Richard Hoare in the early years of the eighteenth century. For many years it was occupied by the Tyrell family, and in 1930 was purchased by Fordson Estates, Ltd. From 1936 onwards the Henry Ford Institute of Agricultural Engineering used the property for short non-residential courses in the care, maintenance and operation of farm machinery, and in the early years of the second world war trainees for the Women's Land Army were given instruction in tractor driving and ploughing. More recently it has been the headquarters of the Boreham Institute of Agricultural Engineering, but as that organisation's activities are now concerned solely with research and development its location has been moved. Last year, Ford Motor Company, Ltd., purchased Boreham House and adjoining land amounting to 72 acres, and put in hand the necessary rearrangement to equip it for its present purpose.

There is residential accommodation for twenty students, and, in addition to a tastefully furnished conference room, students lounge, dining and games rooms, there are a cinema and well-equipped lecture rooms. A view of one of the latter is reproduced on page 721. One of the outside buildings has been converted as a demonstration room for the company's tractors and a big selection of the implements which they operate. Furthermore, the 72 acres of adjacent land are cropped so that every tillage operation can be demonstrated for the longest possible period each year.

National Physical Laboratory

LAST Friday was an open day at the National Physical Laboratory and the following notes provide an outline of some of the principal items of research in progress.

Aerodynamics.—Most of the work in the high-speed laboratory is designed to investigate the fundamental problems of the flow of air at speeds approaching or exceeding the speed of sound, and in particular to give comparisons with the predictions of theory or provide data on which new theories can be based. For much of this work, large wind tunnels are not required and most of the existing tunnels are, therefore, comparatively small. Larger tunnels are needed for some tests and this requirement is being met by the erection of tunnels with working sections 36in by 14in and 25in by 20in in a new laboratory which has now been completed on the West Aero site. Details of the existing and new tunnels are given in the table :

High Speed Wind Tunnels at the N.P.L.

Dimensions of the working section (inches)	Range of Mach number	Range of stagnation pressure (atmospheres absolute)	Type of tunnel
18×14	0 to 1·8	1 to 3	Induced flow
9½×9½	0 to 1·8	1	Induced flow
9×3	0 to 1·8	1	Induced flow
2×2	0 to 1·8	1	Induced flow
20×8	0 to 1·6	1	Induced flow
11×11	1·3 to 2·8	0·2 to 1	Continuous
2·6×1·5	0 to 4	0·3 to 20	Continuous
*36×14	0 to 1·8	1	Induced flow
*25×20	0 to 1·8	1	Induced flow

* Not yet completed.

Swept-Back Leading Edges at Supersonic Flow.—If the leading edge of the wing of a supersonic aeroplane is swept back sufficiently, the conditions there resemble those for subsonic flow and the wing can have a rounded nose similar to that of a conventional subsonic section. The performance of such a wing at supersonic speeds depends critically on the amount of suction which occurs over the rounded leading edge, because a high suction generated over an appreciable extent of the wing chord near the leading edge will reduce the drag. The experiments in progress are designed to give a comparison between the actual flow near the leading edge of a swept wing and that predicted by the existing theory which is not exact and is known to be unreliable in certain cases. The experimental observations include pressure measurements at the surface of the wing and measurements of the lift, drag and pitching moment by means of a strain-gauge balance.

Thin Aerofoil Sections at High Subsonic Speeds.—One of the most powerful methods for obtaining satisfactory performance at high speeds is to use thin wing sections, and many current aircraft have wings whose thickness lies between 8 and 10 per cent of the chord. Future high-performance aircraft may have thinner wings, however, and tests are in progress on a 4 per cent thick wing section. Thinner wings (down to 3 per cent thick) are awaiting tests.

An Interferometer for Measuring the Air Density in High-Speed Flows.—In some experiments (e.g. when the wing under test is very thin or when it is oscillating) it is difficult to use conventional methods for making detailed observations of the flow, and the use of optical methods becomes desirable. The schlieren optical methods are widely used, but it is difficult to obtain quantitative measurements with them ; when quantitative results are required the most suitable optical method is to use an interferometer to measure the density of the air in the field of flow. A small interferometer has been constructed to investigate the usefulness and difficulties of the method, and was shown on the 9in by 3in high-speed tunnel.

Metallurgy Division.—The creep laboratory has developed a design of extensometer which has been modified by the National Gas Turbine Establishment and made in a ceramic material by K.L.G. Sparking Plugs, Ltd. With this extensometer it is hoped to attain test temperatures of 1400 deg. Cent. and preliminary tests have already been carried out at 1200 deg. Cent.

An electrical strain recorder was displayed which uses as the sensitive element a transformer whose output can be varied by moving the soft iron core. The variation in output thus achieved can be amplified and used to give a continuous record. Apart from the advantage of a continuous record this type of extensometer has a large range for a given sensitivity, and fracture of the test piece will not damage the instrument. Also, it is thought that after development the overall sensitivity of measurement will be as good as the more conventional mechanical kind of extensometer now being used, so that valuable comparisons of performance can be made.

In the foundry there are two types of specialised melting furnaces designed to maintain a high degree of purity of the molten metal. The first is a high-frequency induction furnace in which 50 lb of ferrous alloys can be melted and cast *in vacuo* or in a controlled atmosphere. Its use enables the production of alloys of very closely controlled composition and in particular the oxygen and other gas content of the metal can be kept to a minimum. The furnace coil, supplied with electrical current at a frequency of 5000 c/s from a 30kW motor generator, is placed inside a large steel tank which can be evacuated to a pressure of 0·002mm mercury by means of two rotary oil pumps working in series. Inside the tank there is a pump for circulating dried hydrogen round the system, finally blowing the dried hydrogen on to the surface of the molten metal, which is contained in a hard-fired pure alumina crucible. By this means deoxidation of the metal is effected and the product of deoxidation—water vapour—completely eliminated from the metal. The furnace is being used to make 50 lb ingots of iron and iron alloys of high purity.

The water-cooled hearth arc-melting furnace has been designed to melt up to 1 lb or 2 lb of metals, such as, for instance, titanium, which in the molten condition is so reactive it cannot be melted in any refractory crucible without very serious contamination. The hearth of the furnace, made of copper, is water-cooled and melting is effected by an electric arc struck between a tungsten tipped, water-cooled electrode and the metal resting on the copper hearth. The furnace can be evacuated, but melting is normally carried out in argon at a pressure of about 30cm of mercury. The argon is purified, after being admitted into the furnace, by melting a large button of titanium which readily absorbs such impurities as nitrogen and oxygen. It is being used for making alloys of a suitable size for subsequent investigation of their constitution by microscopic and X-ray examination.

Metrology Division.—To meet a growing demand for higher precision in the measurement of internal diameter the N.P.L. has in recent years carried out development work resulting in the design of three new comparators which enable the diameters of reference rings to be determined to an accuracy of the order of ±0·000001in (±0·25μ).

Two of these instruments are similar in basic design, the one accommodating rings with diameters in the range 0·1in to 3in (2·5mm to 76mm), and of depth up to 3in (76mm), and the other rings with diameters in the range 1·5in to 6in (38mm to 152mm), and of depth up to 12in (305mm). The diameter of a given ring is established by comparison with a reference standard of box form built up from high-precision slip gauges and end plates. A double-ended stylus, arranged to contact on each end of a diameter in turn, controls the angles which the reflecting surfaces of a pair of mirrors present to the incident light from an autocollimator, and displacements at the points of contact result in relative displacement of the images of the cross wires as viewed through the eyepiece. Differences of size between ring and standard are thus given in terms of angular measure as read on the micrometer scale of the autocollimator. The factor of conversion from angular to linear measure is an experimentally predetermined constant of the instrument.

The instruments described above are essentially applicable to the measurement of a single diameter, or of several specified diameters, of a given reference ring. For variation in diameter throughout the ring a supplementary instrument, using the pneumatic principle, is available, and has the advantage of speeding up the observational work. This pneumatic comparator, allows variations, both axially and in azimuth, to be measured to the same order of accuracy as with the other two instruments. The separation of two anvils, contacting simultaneously on opposite ends of a diameter, controls the size of an orifice forming part of a pneumatic circuit. Variations in diameter result in variations in air pressure, which actuate a pressure-sensitive indicator.

Amongst other exhibits was the surge generator rated at 3·2MV and 77kW-seconds, to which reference was made in our issue April 30, 1954. The work and equipment in the new metallurgical tracer laboratory was mentioned in connection with its formal opening last month. In the light division, development continues on the application of Moiré fringes to measurement, and its use in the automatic cycling of machine tools.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. V—(*Concluded from page 681, May 7th*)

THE second paper read on the morning of Friday, April 9th, was :—

FRICTION AND FORM RESISTANCE IN TURBULENT FLOW, AND A PROPOSED FORMULATION FOR USE IN MODEL AND SHIP CORRELATION.

By G. HUGHES, D.Sc., Ph.D.

SUMMARY

The paper gives the results of further experiments on the friction resistance of smooth plane surfaces in turbulent flow. The work covers a range of Reynolds number from 0·03 to 250 million, and a range of length/breadth ratio of the surfaces from nearly zero to 64. Submerged plates and sheets and shallow draught pontoons were used.

It is shown that these results conform to a skin friction formulation represented by a family of lines of specific resistance to base Reynolds number. The basic line is for infinite aspect ratio or two-dimensional flow without edge effect. The lines for other values of the length/breadth ratio are at constant percentages above the basic line. Formulæ for the basic line are given.

Some experimental results with submerged cylinders are given. These show that the effect of transverse curvature is to make the slopes of the friction lines steeper than for plane flow.

The application of this work to hull resistance is considered. From the results of a number of model hull tests at low speeds it is concluded that form resistance also varies with Reynolds number as a constant percentage of the basic plane friction resistance similarly to the edge effect of plane rectangular surfaces. A universal law to this effect is stated.

Model and ship correlation using the proposed formulation is discussed, and comparisons are made with the Froude and Schoenherr methods.

DISCUSSION

Professor A. M. Robb : I would like to discuss Fig. 14 [of the paper] where Dr. Hughes presents a very attractive diagram showing the analysis of hull resistance into friction, form and free surface resistance. What justification has he for separating out free surface resistance from form resistance, which, he makes clear at an earlier stage in the paper, is a resistance associated with pressure distribution ? He must be aware that many years ago Lord Kelvin presented a diagram of a wave pattern which tallies very closely with the facts, and that wave pattern was due to a travelling pressure point. If he is not satisfied that the wave pattern is merely the manifestation of a pressure distribution, I suggest he should refer to a set of experiments made in the Taylor Model Basin on a cruiser in shallow water, where the experimenter definitely records the gradual disappearance of the stern wave system with increasing speed. That disappearance is certainly associated with the dying away of the aft pressure peak, almost certainly due to that phenomenon and separation of flow. I suggest, in view of the evidence from the cruiser, that it is quite impossible to separate out free surface resistance and frictional resistance.

On a minor point of principle, in the section in which he deals with experiments with submerged cylinders (page 13), Dr. Hughes states that " instead of a single line for all values of Reynolds number as would be the case if there were no curvature effect or a constant percentage curvature effect, the results show an effect of transverse curvature decreasing fractionally with increase of Reynolds number." They show nothing of the kind. They show really a departure from the effect of geometrical similarity. Dr. Hughes has stated the correct principle earlier in the paper (page 7), where he says that we get a single line with viscous flow if there is geometrical similarity.

The Rev. R. T. Shiells : I am particularly interested in the low range of Reynolds number tests—70,000 being the lowest—performed by means of struts ¼in, 2in and 4in long, measured in the direction of motion. These tests, though outside the normal practical range, form a very valuable addition to our knowledge. It was a real achievement to obtain consistent values of C_f for $t/l=0$, in view of the strain on accuracy imposed by having to determine C_f as a small difference between two relatively large quantities, as will be seen from Figs. 1, 2 and 3. Thus, in the extreme case of the ¼in strut C_f has a value of just over 0·01, whereas the total strut resistance ranges from 0·02 to 0·07, according to the thickness.

These relatively deeply immersed struts would experience only viscous resistance, and Dr. Hughes has assumed (*a*) the resistance of the square cut edge is directly proportional to the thickness ; (*b*) the resistance due to the tapering after end is proportional to the square of the thickness. I feel that the latter is doubtful and would like to know whether it has a sound theoretical basis.

A second problem comes to my mind. The paper states that the square leading edges of these struts produced turbulent flow over the complete length, except possibly the first 1/10th in to 1/5th in as deduced by Dr. Hughes from the comparison of his line (2) with the Blasius line. Last year, when I gave an account of the determination of the resistance of ¼in sand strips by measuring experimentally the resistance of a 1½in strut in the bare and sanded condition, Dr. Hughes suggested that the result was probably too large, due to the neglect of the turbulent flow on the last ¼in of the strut aft of the sand strip. How is it that Dr. Hughes considers that his struts, with leading edges ranging from 0·02in to 0·08in wide, produced turbulence, whereas mine, with a machined edge of 0·031in, apparently did not ?

I put forward a tentative explanation of the anomaly, namely, that at low Reynolds numbers it does not matter numerically whether the flow is laminar or turbulent, since at very low Reynolds numbers the numerical difference in C_f value is negligible. Even in fully turbulent flow, except for a very rough surface, there is always a thin laminar layer. Since both are always present, it would seem that a formula containing a laminar and a turbulent term might well have a theoretical basis.

Professor A. D. Young : I find this paper interesting and disturbing. Perhaps the most disturbing feature is the fact that Dr. Hughes bases the skin friction law at 10 per cent or more below the Schultz-Grunow or Prandtl-Schlichting laws, which are used for skin friction calculation. Those laws have been used in aeronautical work with apparently satisfactory results, and I would like to examine whether Dr. Hughes' own basic skin friction law is as well founded as it appears from an initial reading of his paper.

I have to bear in mind that the Schultz-Grunow or Prandtl-Schlichting relations are fundamental to all the techniques and methods of direct analysis, drag pitch and form pitch, in aircraft work, and if indeed there were a 10 per cent error I find it difficult to believe that it would not have been soon apparent, and that in consequence we would have discarded the basic Schultz-Grunow or Prandtl-Schlichting laws some time ago. In fact, we have calculated the basis of those laws, we have checked the drags of wings and bodies in flight and in the wind tunnel by direct and indirect measurements, and it seems to be well justified. Consequently, whilst believing that Dr. Hughes has made a very profound contribution to this subject, in some respects, particularly at high Reynolds numbers, I suggest that he may have been somewhat enthusiastic in making deductions from his measurements.

Professor E. V. Telfer : I must take the side of Hughes against Young because we are naval architects here. Those who have eighty years' experience behind them of the use of model experiments and the prediction of ship results could say that they refuse to believe there is anything wrong with Froude, for otherwise they would not have carried on with that law for so long.

I respect the work which Dr. Hughes has given us in this paper and his previous one. Most of you know that I have a line of my own. The Telfer extrapolator now lies midway between the Schoenherr and Hughes lines over the whole practical range from the model experiments to the ship, so that whatever compromise may be necessary between the two lines, I am sitting pretty. I should like to show Dr. Hughes where he is wrong in presuming that the square edge will give turbulent flow. Over a very wide initial entry zone of the square edged plate there must be a return flow, and where the turbulent resistance should have been the most intense it is not. If you plot, for example, local friction starting from the leading edge you will see the effect on the average resistance you will build up on a flat plate, and I suggest that Dr. Hughes has completely removed that resistance mechanism by having a square edge. The whole question of turbulence induction is in its infancy, and we have to find a way to make laminar boundaries not quite so stable as they appear to be.

Mr. H. Lackenby : I will confine my remarks to the end product, the new Hughes S.F. line, and will consider its relation to other formulations and the consequences of its adoption. How does this new line compare with other well-known formulations, in particular the Schoenherr line, which is perhaps the most well known ; there are others which give almost the same answer, such as the Prandtl-Schlichting and the Schultz-Grunow. Above $R_n=10^8$, which includes the range in which we are interested in ship work, the new Hughes line is very nearly parallel to the Schoenherr line, but some 12 per cent below it. This is an appreciable difference, very much more than the differences between the other contesting lines. Incidentally, it is 4 per cent below the Hughes line of 1952.

As regards the Schoenherr line, Dr. Hughes explains away the 12 per cent difference on the fact that Schoenherr disregarded the length/breadth ratio effect or edge effect. That may be the answer. There are, however, other lines and data in this upper region. There is the Prandtl-Schlichting line, which is almost identical with the Schoenherr line, and was developed from fundamental work on pipes. A further development of that is the Schultz-Grunow line, which involves a very slight adjustment to suit some measurements of local skin friction made on an inset plate in a wind tunnel. So far as I know, there is no reason to suspect that these measurements are affected by length/breadth ratio or other effects.

Coming nearer home, we have the Jones

and Williams experiments on a flat plate in the tunnel at the N.P.L. Again, these are in the upper region and, so far as I know, there is no reason to suspect them. I may mention also the paper by Landweber to the Society of Naval Architects and Marine Engineers, which gave a boiling down of all available boundary layer investigations, which again tended to confirm the upper regions. So that, even ignoring the Schoenherr line and its supporting data, there is still a lot of evidence and data which there is no reason to suspect in the higher region. Somebody is wrong and we must find a satisfactory explanation for these differences: opinions are not sufficient ; we have to explain the differences scientifically.

If Dr. Hughes, with his long pontoons, had had a few inset plates and had measured the total resistance on those plates and plotted the results against a Reynolds number based on the length from the fore end of the pontoons, he would have got local skin friction. It is a pity he has not done that, for it would have been a check on his line, because with these measurements of local friction there is very little question of edge effect coming in.

Dr. Hughes attempts to take into account the effect of form by taking the extrapolator as a constant percentage higher than the basic line. This leads to an increased slope, and in applying it to the 500ft ship at a speed of 15 knots, the 16ft model gives a prediction of 40 per cent less than Froude and 20 per cent less than Schoenherr. The 20 per cent difference is due almost entirely to this artifice of assuming the form effect on skin friction as being a constant percentage of the plank friction. I think it is a fairly reasonable assumption, but I do not think the evidence adduced in the paper for it is overwhelming. In Figs. 15 (*a*) to 15 (*g*) there is a very restricted range of Reynolds number and the scatter in some places is quite appreciable. We shall need more evidence than that and I am glad that at the N.P.L. they are going to do something about this by carrying out tests on double models, presumably at higher Reynolds numbers.

Mr. K. C. Barnaby : While these very important experiments take us to a higher Reynolds number than has hitherto been possible, they have had to be carried out at aspect ratios that are very far removed from ship practice. If we take the equivalent breadth for a ship form as wetted surface divided by length, normal ship ratios are only about 5·0. The highest value might be about 10 for a destroyer in the light condition, but this would be a very exceptional figure. Dr. Hughes' longest pontoons had a length/breadth ratio of 64, or more than ten times the average ship ratio.

In order to bring these high ratio results to the basic conditions of $l/b=0$, a very large correction has to be applied, and may involve some error. For this reason it might seem preferable to consider the new coefficients as fully valid over a rather more limited range (say), log. $R_n=6·0$ to log. $R_n=8·0$. The lower limit would cover the model range. If we plot these values in the Telfer manner of the inverse cube root we obtain a straight line and we have only to swing the Telfer extrapolator through a small angle to obtain virtual coincidence. A hasty examination shows a line with the formula $C_f=0·0125+0·294\ (R_n)^{-\frac{1}{3}}$. The average divergence of this line from Dr. Hughes' experimental points is only about 1 per cent as compared with about 10 per cent from the Schoenherr line. This seems a rather striking confirmation of the Telfer formula with the same negative index of one-third, but slightly adjusted coefficients.

The final session of the spring meeting was held on Friday afternoon, April 9th, with Sir Stanley V. Goodall, K.C.B., O.B.E., in the chair, when two papers were read and jointly discussed. The papers were :—

MODEL EXPERIMENTS ON A SERIES OF 0·65 BLOCK COEFFICIENT FORMS. PART I.—THE EFFECT OF VARIATIONS IN *LCB* POSITION AND BILGE RADIUS ON RESISTANCE AND PROPULSION

By N. V. Almy and G. Hughes, D.Sc., Ph.D.

Summary

The paper describes resistance and propulsion tests carried out for the British Shipbuilding Research Association on a methodical series of models of fast merchant ship form, having a block coefficient of 0·65. The models were designed at the Ship Division, National Physical Laboratory, where most of the experimental work was undertaken. The main objects of the experiments were to determine the effect on resistance of systematic variations of the position of the longitudinal centre of buoyancy and of the bilge radius, and also the effect on propulsive efficiency of the same variations in the position of the longitudinal centre of buoyancy, the bilge radius remaining constant. For the resistance experiments all the models were first tested without any turbulence stimulating device fitted, but selected models were later tested with a trip-wire 1/20 of the length aft of the forward perpendicular. For the propulsion experiments three different propellers were used on each of the models tested.

The results of the resistance tests show that the effect of change of bilge radius is generally small and somewhat irregular, but that, in terms of the 400ft ship, a radius of 8ft to 10ft gives the least resistance at the load and medium draughts. At the ballast draught a radius of 6ft to 8ft is more favourable. The main effect of shift of *LCB* position is that, within the range of the experiments, the maximum economical speed increases from about 15 knots to 17 knots for the 400ft ship as the *LCB* is moved aft from the position ½ per cent of *LBP* forward of amidships to 1½ per cent aft. For speeds of less than 15 knots change in resistance due to shift of *LCB* position is small, although the most forward position is slightly more favourable.

The effect of shift of *LCB* position on quasi-propulsive coefficient is small, but the effect of change of propeller diameter and revolutions per minute is much greater. At the load draught the QPC is about 5 per cent greater with the largest diameter propeller than with the smallest. This difference is, however, smaller than the corresponding increases in propeller efficiency since these are largely offset by reverse changes in hull efficiency.

MODEL EXPERIMENTS ON A SERIES OF 0·65 BLOCK COEFFICIENT FORMS. PART II.—THE EFFECT ON RESISTANCE OF VARIATIONS IN BREADTH-DRAUGHT RATIO AND LENGTH-DISPLACEMENT RATIO

By J. M. Ferguson and M. Meek, B.Sc.

Summary

Part II of the series of model experiments on 0·65 block coefficient forms deals with tests made to the order of the British Shipbuilding Research Association on a methodical series of nine forms derived from the parent form described in Part I. The effects on resistance of varying the breadth-draught ratio and the length-displacement ratio are examined. The tests fall into two groups: (*a*) one giving a range of breadth-draught ratio with constant displacement and length, and (*b*) one giving a range of length-displacement ratio with constant breadth-draught ratio.

The results show that the effect of increasing the breadth-draught ratio above that adopted for the parent form is to increase the resistance generally, this increase being greatest at the lower values of speed-length ratio. Above a certain critical value of breadth-draught ratio, however, the resistance begins to decrease again. Decrease in length-displacement ratio, i.e increase in displacement, gives an increase in resistance generally, the effect being greatest at the higher values of speed-length ratio. This increase in resistance, however, is not of a regular character over the range of length-displacement ratio examined.

Discussion

Professor A. M. Robb : With regard to the first paper, I am one of the generation who was brought up to believe that tank experiments told nothing but the truth, and that until we get to high speed-length ratios it pays to keep down the prismatic coefficient, which means that we must use the largest possible midship area. There is a tremendous amount of data which seems to justify that statement ; and now this paper throws out the whole thing.

As regards the second paper, I was especially intrigued by the comment about the resistance decreasing at beyond particular values of L/B. On the accepted basis the wetted surface steadily increases at beyond a minimum value of L/B ratio ; so that if the resistance begins to decrease the effect can only be in the residuary resistance. I suggest that the authors might plot some values of residuary resistance per ton of displacement ; if they can make sense out of them I shall be glad to know it.

Professor Weinblum : Nowadays model series work should be treated as a serious scientific problem, not as a job of running a couple of models. The two papers presented meet this requirement to some extent.

With respect to the first paper, it is a pity that the need for artificial stimulation has been recognised so late. The authors' explanation as to the probable stimulation effects in the case of the bilge radius tests may be plausible, but it is not convincing. It would have been preferable to have kept the form of the sectional area curve, varying the bilge radii. The principal subject—the influence of the *LCB* variations on the resistance—has been clearly demonstrated. The effects can be explained by wave phenomena, but it would be helpful to have the results of two double models, which would furnish data on the viscous drag, especially on the viscous pressure resistance.

Referring to the second paper, I would recall the authors' statement that former work of a similar character has suffered from two shortcomings, the simultaneous variation of several parameters and the narrow speed range. This criticism is to the point, except for D. W. Taylor's " Yorktown " test dealing with the beam-draught effect. Taylor found a trend similar to that found by the authors in the range of speed-length 0·9 to 1·1 ; and he stated that there was no resistance increase when increasing the B/d ratio from 3 to 3·5, but there was a definite increase from 3·5 to 4.

The investigation of the $L=L/\nabla^{\frac{1}{3}}$ (length-displacement) effect also follows D. W. Taylor's lines. The presentation based on the K value is not too fortunate.

In regard to the tank influence, the approach used in analysing the " Lucy Ashton " data quoted by the authors is consistent in principle, but not quite adequate in respect of details. It is reasonable to assume that a blockage effect and a wave effect can be treated independently to a first degree of accuracy. The blockage effect can be calculated following a method proposed by Lock (Reports and Memoranda). The wave correction should be computed from Sretensky's integral, which is the analogy to Michell's solution, valid for the motion of a thin ship in a rectangular channel. Mr. Wigley calculated the resistance of a Rankin's ovoid under the same condition. From an inspection of the curves for various draughts it appears doubtful that agreement will be reached between the results obtained in both tanks by applying the frictional corrections.

Professor E. V. Telfer : In connection with the blockage effect, it is interesting to note in Fig. 24 of the paper by Mr. Ferguson and Mr. Meek, for example, where the model 3241 was tested in both tanks at Teddington, that the fact that the larger tank has substantially twice the area of the smaller allows one to say, in view of my own North-East Coast paper of last year, that whatever difference is found between the two tanks at Teddington can be put as a reduction of the C found in the bigger tank there. In other words, because the blockage of the bigger

tank is only half that of the smaller, you have whatever difference is found between the two tanks as the next step towards the infinite width.

By comparing Fig. 24 with Fig. 26, where you have the same model tested at a shallow and a deeper draught, the effect of blockage was smaller in the case of the shallow draught than in the case of the deeper one. That again appears to be in line with what we should expect from blockage theory.

With regard to Professor Robb's point, I did examine the influence of prismatic coefficient and it seems that you can best distinguish in this way that at the residuary and frictional resistance being considered, the effect of the prismatic coefficient keeping up is always to increase the residuary resistance ; but when you combine the frictional with the residuary you find that the effect of the greater bilge radius is to improve the wetted surface efficiency; there is a drop in *C* at low speeds, but because of the greater prismatic coefficient that effect is overcome at the higher speed-length ratios.

Professor Robb may have found some exceptions to that particular case ; but, going quickly through the broad facts, that is how I felt it was working out, which is rather interesting because I had felt up to that point that the prismatic coefficient was a completely erroneous variable to use ; it seemed to have virtue if confined only to residuary resistance.

In addition to the complexity in the results caused by tank interference, you have also the other complexities introduced by the different sizes of model, and you see a number of cases where models have been tested, and I think, largely owing to the Froude formulation being used, they do not confirm one another. That is rather distressing, and eventually it means that the whole of this magnificent paper will have to be converted into standard form, allowing for these differences as they come along.

Technical Reports

The Use of Stabilised Soil for Road Construction in the U.S.A. Road Research Technical Paper No. 29. H.M. Stationery Office, London. Price 2s. 6d.—This report is based on material collected by a member of the staff of the Road Research Laboratory during a visit to the U.S.A. in 1951 to study American practice in soil stabilisation. It deals first with techniques for soil survey, the classification of soils and the design of pavements. Methods of stabilisation using cement, bituminous materials and chemicals are then described in detail and the performance of main, secondary and urban roads constructed in this way is considered. A section on mechanical plant for stabilised soil road construction deals with mix-in-place equipment, travelling-plant-mix equipment and miscellaneous plant.

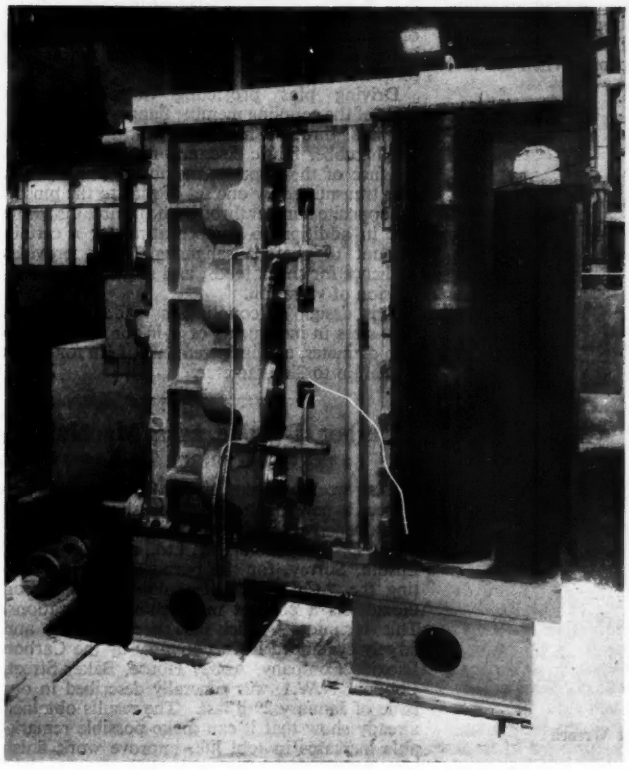
Dynamic Stresses in Cast Iron Girder Bridges. National Building Studies Research Paper No. 19. H.M. Stationery Office. Price 3s.—The Building Research Station has studied over many years the strength of short-span road bridges. Out of this work new methods of calculating live load stress from static loading tests were developed which were more accurate than those previously used. It was usual to add an impact allowance of 50 per cent to the calculated stresses for bridges of less than 75ft span. In order to learn more about dynamic effects the Station carried out the two series of tests with moving vehicles on cast iron girder bridges described in the present publication.

Six bridges were selected for test and the loading vehicles included steam rollers, heavy lorries, a Churchill tank and a Diamond-T transporter. It was expected that the effect of a vehicle on a bridge would be constant during identical runs but the test results showed that this was not the case, the variation probably being caused by the bounce of the vehicle on its springs, even when the road surface was smooth. The two series of tests gave similar distributions of the impact factor and maximum values of about 1·3.

The report describes methods of testing, the apparatus used and the results of each of the two series of tests. It also discusses the theory of dynamic stress and compares theoretical predictions with the test results.

Hydraulic Plate Bending Press

PARTICULARS have been received from Hugh Smith and Co. (Possil), Ltd., Glasgow, of a new heavy-duty plate bending press it has developed, in which the hydraulic rams act directly on the bending beam. In older machines of this kind it was usual to employ toggle links or a roller wedge action to give the necessary increase in pressure, but with the use of higher pressures—in the case of the machine illustrated 4500 lb per square inch—intermediate leverage is dispensed with.



Direct-Acting Hydraulic Plate Bending Press in Operation

In heavy plate bending work, such as plates of 1¼in thick and over, it has always been difficult to obtain the necessary preset of the plate edge before producing a complete circle. For such heavy plates, therefore, it has been common to use a separate hydraulic press and suitably curved forming dies to upset the edge before rolling. But the makers point out, with this new machine, where very powerful hydraulic rams can be brought to bear close to the edge of the plate, no separate presetting is necessary and a considerable saving is effected in initial and in operational costs. A further advantage of using a machine which can bend the plate close to the edge is that the butting edges of a drum can be accurately machined to the correct welding profile before bending.

Owing to the increasing use of higher pressures in various types of vessels nowadays there is an increasing demand for small diameters to be produced in thick plates, and the new direct-acting press is stated to have ample power available for producing these very small diameters in heavy plates. In addition, any " hard " areas in a plate can be given extra set locally without difficulty. In modern welding fabrication work there is now a tendency to flange more plates to shape rather than cut and weld, and on this shell bender right-angle flanging work can readily be done in very heavy plates. When flanging plates over 1in thick to a small internal radius, however, it is necessary to use a ductile quality of plate to withstand the severe bending stresses which can be applied hydraulically.

One of the new machines is illustrated on this page. It has a bending power of 1200 tons and a plate capacity of 10ft by 1¼in mild steel, and on the machine mild steel drums can be bent down to 4ft diameter. With the use of a smaller interchangeable roller it is possible to bend thinner plates to much smaller diameters, but in such cases the power must be reduced to prevent overstressing the small-diameter roller. The pumping and valve equipment is of Towler Bros. " Electraulic " design and the solenoid operated valves are arranged for either automatic or inching operation. Once set in motion, the bending procedure is automatic and the main roller around which the plate is bent is rotated automatically by a small amount at each bending operation. The four rates of feed available are 2½in, 3in, 4in and 6in per stroke, and these feeds can be changed either whilst the machine is in operation or at rest. The amount of set given to a plate is variable by means of handwheel control. The feed roller is arranged so that it can be lifted out complete with its top bearing by means of a crane for a complete drum to be readily removed.

Instead of a roller this machine can be supplied with a fixed beam and inset feed roller. This inset roller is interchangeable, so that flanging nose bars can be fitted for 90 deg. flanging work. The width of bending centres of the reciprocating beam is variable so that very heavy plates can be bent to larger diameters when necessary. These presses can only be supplied complete with electro-hydraulic equipment and they are not suitable for use from water hydraulic mains supply.

An order is at present in hand for a 3000-ton press of this kind which is capable of bending plates cold up to 3in thick.

Diamond Die Profiloscope

A DIAMOND die profiloscope has now been introduced by the British Iron and Steel Research Association which operates on the same principle and extends the range of the existing B.I.S.R.A. profiloscope, which was described in THE ENGINEER, May 22, 1953, page 735.

The principle on which both instruments operate is the simple one whereby a narrowly divergent light beam is passed through the die to be examined, on to a screen below. Changes in taper show as concentric light circles, one for each taper, while a gradual change in taper causes a wider band of light. Scoring shows as lines radiating from the centre spot, while cracks and ringing also have distinctive and easily recognisable effects on the pattern.

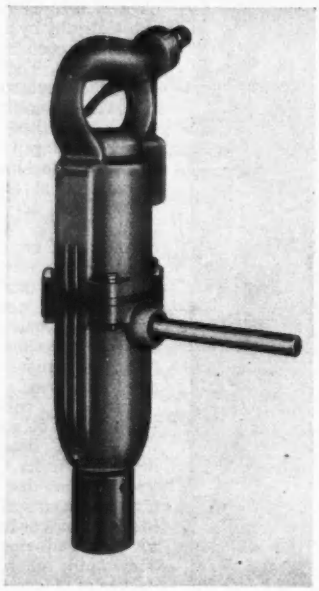
When the front-silvered mirror is rotated by means of a control knob on the front of the instrument (these being the only moving parts) the light beam strikes the die obliquely. This has three effects. It intensifies the pattern of the image ; it extends it to cover the sizing portion and the back relief ; it distorts the annulus and it makes possible very simple measurement of the die angle. The scale on the control knob is easily read to 15 seconds or less by an unskilled operator.

The die itself is held in a clip on which it can be quickly centred. The light source, which must be very powerful to give sufficient illumination through such small bores, is provided in Type I (all die bores down to 0·002in diameter) by a mercury vapour lamp, and in Type II (die bores down to 0·010in) by a tungsten filament lamp.

Pneumatic Impact Wrench

We reproduce below a photograph of a new impact wrench being made by Holman Brothers, Ltd., of Camborne, Cornwall. It can also be used for drilling, tapping and tube expanding.

The tool is driven by a vane air motor and impact for tightening or loosening nuts is delivered by a piston impelled by high-pressure air generated by the motor supply. It is designed for very rapid acceleration of the striking hammer to give a high value of impact. When the tool



Pneumatic Impact Wrench

is used for screwing up a nut impacting commences when the resistance reaches a predetermined point and continues until the nut is fully tightened. The machine is reversible, and when unscrewing the impacting commences immediately and continues until the nut is released sufficiently to be spun off by the rotary motion.

The wrench is suitable for heavy-duty operation on ⅜in nuts and up to 1in nuts in normal operation. It is stated to be capable of removing bound nuts which would otherwise have to be cut or burnt off, and the output spindle takes 1in square drive chucks.

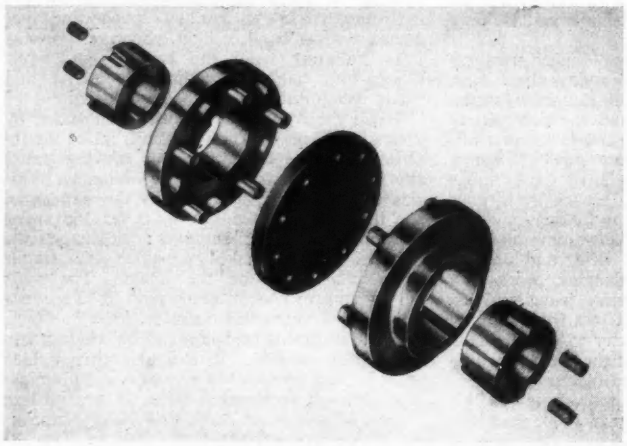
Flexible Coupling

A flexible coupling which is attached to shafts through the medium of "Taper-Lock" bushes is now being made by J. H. Fenner and Co., Ltd., Marfleet, Hull. One of the new couplings in its component parts can be seen in the accompanying illustration.

The bushes are tapered on their outside diameters and are bored parallel and keywayed in accordance with the shaft sizes. Each bush is split longitudinally and, when inserted into the tapered bore of a coupling member setscrews are screwed in the threaded sections in the coupling member. As the screws are tightened they serve to draw the bush into the bore and close it in to grip the shaft firmly. The angle of taper in the coupling member bore and on the outside of the bush is such that the wedging action imparted is sufficient to transmit the full driving torque.

Driving pins projecting from the inner faces of the coupling member flanges are designed to pass through holes in centrally disposed tough rubber fabric disc, and register in slots in the face of the opposite member. The drive is thus transmitted by one set of pins to the pins in the opposite number through the flexible disc. The disc in addition to compensating for a certain amount of shaft misalignment, also provides resilience for shock loads, and reduces the transmission of vibration.

This design of coupling is made in various bore sizes in increments of $\frac{1}{16}$in for shafts up to 1¼in diameter, and in increments of ⅛in for shafts from 1⅜in to 3in diameter.



Components of a "Taper-Lock" Bush Flexible Coupling

Carbon Dioxide as a Machining Coolant

Last week we were given the opportunity to inspect a new engineering workshop which has been opened at the central research establishment of the Distillers Company, Ltd., at Great Burgh, Epsom, Surrey, for the purpose of demonstrating the "CeDeCut" technique using carbon dioxide as a coolant in machining operations. This technique, which has been applied and largely developed in this country by the Carbon Dioxide Company, Abbey House, Baker Street, London, N.W.1, was generally described in our issue of January 29th last. The results obtained already show that it can make possible remarkable increases in tool life, improve work finish and speed machining with difficult materials. A large amount of research yet remains to be done to develop the technique to its fullest commercial possibilities in a wide field of application. The new engineering workshop has been equipped for this research work, which is being supplemented by that done by a number of industrial firms already using the technique in their machine shops. Up to the present all the expenses entailed in primary development of the technique have been met by the Distillers Company, but we learn that in the future financial assistance will be given by the Ministry.

The new engineering workshop is equipped with a useful range of lathes, a milling machine, a drilling machine, a shaper, and grinding machines for research work and demonstrations using carbon dioxide as a coolant. This shop is supplied with carbon dioxide from a mains system fed from an adjacent bulk storage unit. During the press visit some interesting demonstrations were given to show the possibilities of the technique. A Fischer lathe was shown machining "EN.25" with a high standard of finish at a speed of 475ft per minute, with a depth of cut of 0·10in and a feed rate of 0·014in per revolution. An H.E.B. lathe was machining "Nimonic 90" at 190ft per minute, the depth of cut being 0·020in with a feed rate of 0·022in per revolution. On a "Victoria" milling machine an end mill was cutting EN.2 at a speed of 110ft per minute with a depth of cut of 0·10in. The grinding machines showed how a controlled flow of carbon dioxide effectively cooled tipped tools during grinding and prevented heat cracking of the metal.

Electric Traction Using 50 c/s Current*

By M. Garreau†

The paper shows why 50 c/s single-phase distribution was adopted by French Railways. The advantages and economies are discussed, and the various types of locomotive drive which it allows are detailed. Some indication of the merits of each is given. Special attention is paid to the C_0–C_0 locomotives using single-phase/direct current and single-phase/three-phase motor generator sets for hauling the numerous heavy freight trains on the Valenciennes-Thionville line. B_0–B_0 locomotives will be used to haul the majority of other traffic over many electrified main lines. The main drives employed are the single-phase motor and the direct current motor with ignitron conversion, for which a great future is predicted.

Behind the initial experiments and final adoption of single-phase 50 c/s traction [on French Railways] lie the desires to obtain the energy direct from the national grid, to transmit high-voltage energy in the trolley wires and to take advantage of the progress in electrotechnology to build mains-frequency locomotives. Since this latter has hitherto been the major stumbling-block, it will suffice to record but briefly the advantages of the first two ideas in relation to the Valenciennes-Thionville line. For example, the 225 miles of this route will now require six substations and 7 miles of high voltage feeder, whereas direct current operation at 1·5kV would have involved twenty-three substations, each more expensive than the alternating current ones, and some 211 miles of high voltage feeder. Moreover, the 25kV, 50 c/s trolley wires require a cross-sectional area of 0·233 square inch, whereas the direct current wires would require an area of 0·744 square inch. The stationary equipment for 50 c/s working is thus expected to cost only 45 per cent of that for direct current working; there is also a considerable saving over the cost of operation at 16⅔ c/s, but it is unnecessary to enter into detailed discussion here.

50 c/s Single-Phase Locomotives

The crux of the matter, therefore, is the feasibility of building satisfactory locomotives to work on a 50 c/s single-phase supply; it is important to mark this distinction between the supply and the motors themselves; for, when the energy has been collected at the pantograph, it may be fed to the motors in many possible ways. It may be converted to direct current energy by means of a rotary converter with Ward Leonard control—a device often used in industry when gradual regulation of speed over a wide range is required. Alternatively, it may be converted to three-phase energy of variable frequency, with synchronous or asynchronous transmission; this arrangement is found in marine propulsion and in industrial drives where it is desirable to use induction motors with more flexibility than they normally possess at constant frequency. Another device is to use mercury-arc rectifiers to supply unidirectional current to commutator motors, and this method is finding increasing application in industry.

None of these methods was available in the early days of electric-traction development; the first two devices were too heavy for the permissible axle loadings, while suitable rectifiers were not available. Progress over the last three decades has changed this situation; for example, the single-phase/direct-current rotary converter of the 6053 C_0–C_0 locomotive weighs 15 tons, and that of the Valenciennes-Thionville C_0–C_0 locomotives 19 tons, whereas thirty years ago the figure would have been 30 tons. The rectifiers weigh even less, the set on the three 120 h.p. B_0–B_0 locomotives weighing only 5·8 tons (including an ample smoothing choke).

The final possibility is the direct feed to single-phase commutator motors, and this will be considered later.

Adhesion and Speed Control.—The successful combination of direct current or squirrel-cage motors and a national system of supply is a considerable achievement, for the voltages at

* Abstract. Institution of Electrical Engineers, London, May 6th.
† Société Nationale des Chemins de Fer Français.

the point of use are confined within more reasonable limits than would otherwise be possible. Moreover, starting and speed regulation are accomplished by control of the generator exciter or the rectifier transformer, which is both more satisfactory and economical than the methods open for completely direct current systems.

The motor itself is more easily constructed, and the performance of the locomotive is improved because the motors can be left permanently connected in parallel and require no large resistors; thus they "back-up" better and reduce the tendency to wheel slip.

This introduces an important point regarding the locomotives of the Valenciennes-Thionville

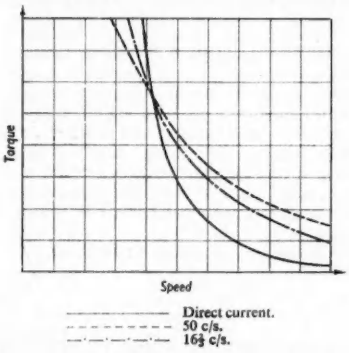


Fig. 1—Tractive-effort/speed curves of commutator-type series motors for various traction systems

line, namely, the best use of adhesion, since this sets the limit to tractive effort. The coefficient of adhesion may be regarded as a ratio between the tractive effort at the wheel rims and the axle loading, below which the wheel grips and above which it slips. The tractive force is increased in successive steps, and the smaller these steps, the more nearly will the mean force approach the limit of adhesion. From this aspect single-phase locomotives with voltage regulation by tapped transformers (locomotives with single-phase motors or rectifier motor combinations) are better than direct current locomotives, since the speed can be regulated more smoothly. Locomotives with single-phase/direct-current rotary convertors are even better, since regulation is achieved through the generator exciter; those with single-phase/three-phase convertors offer the same advantages if the frequency is regulated

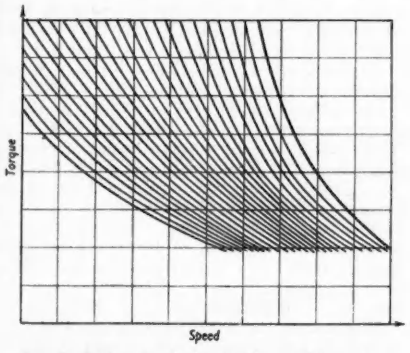


Fig. 2—Influence of the starting resistances on the torque/speed curves of a d.c. motor

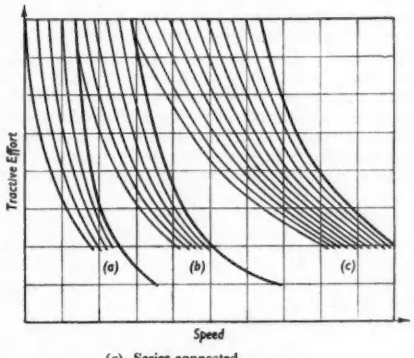
through the exciter of a direct-current generator, as is done on the Valenciennes-Thionville locomotives.

Factors Affecting Wheel Slip.—If the slightest increase in the speed of one axle relative to the others always resulted in wheel slip, slip would occur frequently; but if this increase were accompanied by an immediate and sufficiently large reduction in the tractive force, the wheel would recover its grip on the rails before slipping became noticeable. Thus the probability of wheel slip decreases (and so the coefficient of adhesion increases) as the speed/torque characteristics of the traction motors become steeper.

Fig. 1 shows the characteristics for the three most common types of traction motor, and from these it would seem that the direct-current motor is the best from the aspect under consideration—as is indeed the case. There is, however, a tendency to go further, and to think that this shows the superiority of the direct current locomotive, but this is not in accord with the facts, since the 120-ton C_0–C_0 locomotives on the Limoges-Montauban line haul trains of only 1200 tons on gradients of 1 in 100, while locomotives of the Valenciennes-Thionville line will have 1800-ton trains on these gradients.

However, another factor which must be considered is the method of supplying the motors. Fig. 1 is drawn for motors in parallel and at full voltage, and does not take account of the conditions of starting and acceleration. With direct current motors these conditions are governed by the controlling resistance, which is reduced in effect as the speed is increased. This device flattens the torque/speed characteristics, as shown for a single motor in Fig. 2. On a locomotive, of course, there are several motors, connected in series at starting and then in series-parallel, which steepens the tractive effort/torque characteristics, as shown in Fig. 3. However, it should not be forgotten that, if there are four motors, in the initial series connection each is not fed at exactly one-quarter of the total voltage unless all are revolving at exactly the same speed. If a pair of the wheels begin to slip, the voltage drop across the motor driving them increases and the slope of the speed/torque curve falls rapidly to about one-quarter of normal, as shown in Fig. 4. This effect is enhanced by the rheostat.

The situation changes completely when the direct current motors are supplied in parallel



(*a*) Series connected.
(*b*) Series-parallel connected.
(*c*) Parallel connected.

Fig. 3—Influence of motor grouping on the tractive-effort/speed curves of a d.c. locomotive

from a variable-voltage generator, as in the single-phase/direct-current locomotives, since speed control within very close limits can be secured in conjunction with the most advantageous speed/torque characteristics (see Fig. 5). This type of locomotive therefore has a better coefficient of adhesion than the single-phase or direct current locomotives.

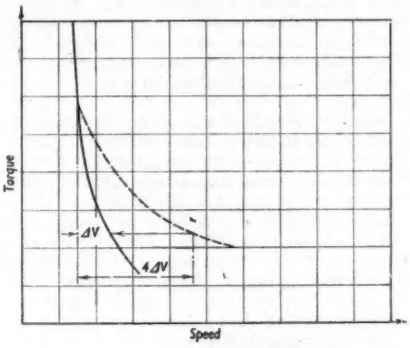
There are other advantages, particularly when starting. In order to commence hauling the heaviest possible load with a given tractive effort, acceleration must be as low as possible. In this respect the familiar single-phase 16⅔ c/s traction motors compare unfavourably with direct-current motors, for they are easily damaged if started too slowly; accelerations of 0·26–0·33ft/sec² are considered normal minima, compared with 0·06–0·08ft/sec² for locomotives with direct current motors supplied through motor-generator sets or rectifiers.

This fact gives a great advantage in respect of the weight hauled; for example, with a coefficient of adhesion of 0·2, a reduction in acceleration from 0·26 to 0·08ft/sec² will permit an increase of 45 per cent in the weight hauled on a gradient of 1 in 100 and of 150 per cent in the weight hauled on the level. If the coefficient of adhesion is also increased—and this has been shown to be possible—further improvements can be secured.

Characteristics of 50 c/s Locomotives

It has now been shown that the single-phase/direct-current locomotive combines smooth control, satisfactory speed/torque characteristics and motors which are unaffected by slow starting; these are the fundamental reasons for their adoption on the Valenciennes-Thionville line, where the problems involve starting and hauling very heavy trains and negotiating considerable gradients.

There remain two further types of locomotive which will operate on the Valenciennes-Thionville line, namely, those with single-phase/three-phase convertors and those with ignitron-fed direct current motors. From the operators' aspect the former are superior to all other types, for the traction motors are simple induction units without commutators; they are not damaged by slow starting, and assist each other when running, since they are linked by the frequency. If one pair of wheels began to run



Motors fed separately.
Motor in series with three others.

Fig. 4—Influence of wheel slip on the torque/speed curve

light, without gripping the rails, the motor driving them would accelerate only until it reached synchronism, so that its speed would exceed that of the other motors by only a few per cent. This means that the axles of a single-phase/three-phase locomotive are coupled like those of a steam locomotive, which can slip only on all axles at once.

Speed control is effected in much the same way as it is on the single-phase/direct-current rotary-convertor locomotives, except that frequency, not voltage, is the controlling parameter. If the asynchronous frequency convertor is driven at progressively variable speeds by direct-current machines coupled to a Ward Leonard system, the finesse of control is the same as that found on the single-phase/direct-current locomotives; this is the principle used on the Valenciennes-Thionville line.

Locomotives of this type are, of course, rather

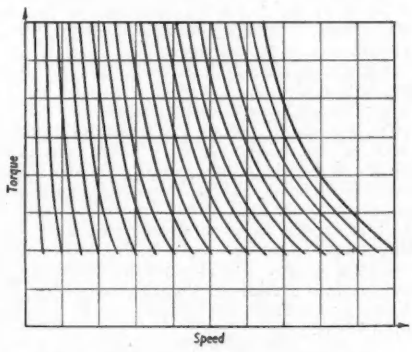


Fig. 5—Influence of voltage variation on the torque/speed curves of a d.c. motor in a convertor locomotive

more expensive than single-phase/direct-current units. They are also more novel, and are not backed by the experience gained from diesel-electric working. Thus, of the eighty-five C_0–C_0 freight locomotives on order for the Valenciennes-Thionville line, only twenty are of the single-phase/three-phase type, the remainder having single-phase/direct-current rotary convertors. It should be added that on both types the motor generator set is driven by a synchronous motor which acts as a power factor compensator and enables the set to operate with a power factor of unity. This reduces considerably the voltage drop in the transmission line and enables the

substations to be more widely spaced ; the overall power absorption is less, with consequent lessening of the load on the transformers and the supply network.

Locomotives with rectifier-fed motors will not play an important part on the Valenciennes-Thionville line, only five B_0–B_0 locomotives having been ordered ; single-anode ignitrons will be installed, and the locomotives will be used for mixed traffic service. The reliability of the valves is not doubted, in view of experience in America and on the Annecy line, and advantage of the five B_0–B_0 locomotives will be taken to study, under operating conditions, the harmonics produced by the single-phase rectifiers, since their effect on the network is difficult to forecast mathematically. Although only five rectifier locomotives have been ordered, their potentialities have not been under-rated, and the S.N.C.F. consider that the type shows great promise.

The remaining fifteen mixed traffic locomotives have the B_0–B_0 wheel-train arrangement and are driven by single-phase commutator motors ; these locomotives are expected to give the same performance in mixed traffic service as that at present accepted as the basis for 1500V direct current B_0–B_0 locomotives. These decisions are based on the experience gained on the line from Aix-les-Bains to La Roche-sur-Foron, where C_0–C_0 locomotives with commutator motors have given excellent service.

The single-phase motors for the Valenciennes-Thionville locomotives have a continuous rating of 680 h.p. at 32 m.p.h., i.e. on a basis of 50 per cent of maximum speed, not the 70 per cent customary for single-phase motors. The transformer is thus limited to an output corresponding to 2720 h.p. (4×680), but a larger unit would permit the motors to operate at 70 per cent of maximum speed and so develop 950 h.p. each. These motors are expected to give quite satisfactory operation on 50 c/s power, while possessing two advantages not normally found in single-phase motors, namely, that they are unaffected by starting conditions and are able to maintain their torque at very low speeds. Another design feature is the ability to withstand, when completely at a standstill, a thirty second power surge equal to the one-hour rating, so that an unsuccessful start will not damage the motor.

This is achieved by providing the motor with resistive connections between the armature winding and the commutator, which limit the current in the turns short circuited by the brushes.

These motors show no loss of torque ; i.e. for a given current the speed/torque characteristic does not droop at low speeds as is often the case with single-phase motors (torque losses of up to 15 per cent being common), so that the advantages normally associated with direct current motors are anticipated.

Finally, it should be stressed that the high proportion of C_0–C_0 locomotives ordered for the Valenciennes-Thionville line (eighty-five out of 105) is a result, not of the system of traction adopted, but of the special working conditions of the line, where the majority of the traffic consists of heavy freight trains of iron ore and coal. On other lines, where the traffic is similar to that carried by those already electrified with direct current power, only B_0–B_0 locomotives will be provided. The locomotives described will be put into service on the first section of the Valenciennes-Thionville line during the summer of this year.

Conclusions

The paper has been confined to pointing out the main reasons behind the selection of the four types of locomotive for the Valenciennes-Thionville line, and to showing that the decision to employ 50 c/s power distribution, with the object of reducing the capital outlay on stationary equipment, has not involved the construction of locomotives which are less satisfactory than those used with other systems. In fact, it is believed that the freedom from the restrictions imposed by direct current or 16⅔ c/s working had led to better designs, because of the ability to use the resources of industrial electro-technology.

The choice of a line carrying the heaviest traffic for the initial experiment indicates clearly that the system need not be restricted to secondary lines ; indeed, consideration is already being given to the extension of the method to other important lines in northern and eastern France.

The French view is confirmed by the Americans, in the Report of the Batelle Institute (June, 1952) ; expert opinion there expresses a preference for 24kV, 60 c/s distribution on future electric railway systems. This conclusion was based on cost comparisons for lines carrying traffic about twice as dense as that on the Paris-Lyons line.

All that is now required is confirmation of these findings by practical experience, and this will be available for the Valenciennes-Thionville line in the near future.

Continental Engineering News

(By Our Continental Correspondent)

Toulouse Sports Arena, France

A sports arena of a rather unusual design was recently erected at Toulouse ; it accommodates 12,500 persons, has an outer diameter of 296ft and an inner diameter of 161ft. A short constructional time was allowed, and so the contractor adopted prefabrication methods which enabled the building to be completed in three months. It comprises a forty-eight-sided polygon, with expansion joints dividing it into five parts. The superstructure is carried on columns set in five concentric polygons. The height of the columns varies between 5ft and 46ft, and they are wind braced by radial and circumferential stiffeners, which were all prefabricated. The columns carry inclined racks on which rest prefabricated rows of seats. The daily output at the site of prefabricated seating elements amounted to some 400ft. Monsieur Montier was the architect and Monsieur Barets the consulting engineer for this structure. The contract was let to the Entreprise Margeridon.

Baudouin Lock, Antwerp

An important lock is now under construction at Antwerp, near the Kruisschans lock, which was built about a quarter-century ago. The Kruisschans lock is 886ft long, 115ft wide and 33ft deep. The new Baudouin lock, which received the name of the present King of the Belgians, will be 1180ft long, 148ft wide and 35ft deep. It is being constructed by the Franki Company, and is making good progress. The two locks are some 800ft apart.

The Baudouin lock consists of two main "head walls" separated by the lock chamber. There are two welded steel sliding caisson gates at each end of the lock, which is generally of reinforced concrete construction.

The "head walls" have steel-sheet-piled cut-offs with the piling driven down to 17½ft under the foundations of the lock.

The lock invert was formed of r.c. slabs, 33ft by 33ft by 3·3ft thick. The gate recesses are 167ft long and 33ft wide, reduced to 27ft at the entrance. The construction of the new lock will require the placing of some 400,000 cubic yards of concrete. Cement is supplied in bulk and stored in two 1500-ton steel silos ; the concrete plant comprises four mixers and there are two tower cranes and other plant for emplacing it as construction proceeds.

Velsen Tunnels, Holland

Two tunnels are now under construction in Holland at Velsen. The tunnels (one for highway traffic and the other one for railway traffic) will pass under the ship canal, linking Amsterdam with the North Sea. Construction was started in 1939, interrupted in 1942, and resumed only in 1952 ; the works are due for completion in 1958.

The highway tunnel will have twin carriageways for motor traffic only and will be some 5500ft long ; the length of the railway tunnel will amount to 10,600ft. The engineers experienced difficult problems, particularly in the ground water lowering, for the tunnels are being built by cut and cover methods. The highway tunnel will consist of twin tunnels, each accommodating a 23ft wide roadway and two 3·3ft footpaths, built in the form of a single reinforced concrete structure, with ventilation and service ducts in the central space between the two carriageways. The railway tunnel will accommodate a double-track line. Because of the use of electric traction, no special devices for ventilation are needed in the railway tunnel.

The quantity of excavation for the new tunnels is estimated at 3,250,000 cubic yards ; about 400,000 cubic yards of concrete will be placed on the contract, which is being carried out by the Amsterdamse Ballastmaatschappij, under the direction of the Dutch Waterstaat (special service of locks and dams).

Kunda Hydro-Electric Works, Belgian Congo

The new Kunda hydro-electric power scheme in the Belgian Congo is situated near Kampene (Kivu). The Kunda dam is 41ft high, forming a lake 3·2 miles long, having a capacity of 6,500,000 cubic yards of water. The dam is of earth-fill construction, and there is an intake gallery, about 2 miles long, including three penstocks spanning deep ravines, leading to the power station. The power station is equipped with two Pelton turbo-alternators of 1000kW.

Closure of Tidal Gaps in Holland

It is well known that the floods of February, 1953, caused extremely heavy damage in Holland.

The largest tidal gap in the Dutch sea defences was near Schelphoek, on the island of Schouwen-Dulveland, through which some 165 million cubic yards of water flowed at each tide. The total number of breaches caused in the 1953 flood was nearly 600, of which sixty-seven were tidal gaps. Of the total 670 miles of dykes in the south-west part of the country, some 300 miles were damaged. At some points, the dykes were completely washed away, as it was the case on the island of Goeree-Overflakkee, where a length of 14 miles had to be completely reconstructed.

In addition to the more conventional materials (brushwood, stone, clay) for dyke reconstruction, reinforced concrete was employed on a wide scale. "Unit" caissons were used for closing the gullies, and for building up the horseshoe dykes in the fast currents of the tidal breaches. The caissons were designed to be built up from standard units on the following basic principles : the width of the caissons had to vary between 24½ft and 49ft and the weight of the water or sand-filled caissons had to be such that they could not be forced out the gap. The weight of the "unit" caisson was not to exceed 200 tons, so that it would be possible to build units on shore and subsequently to place them in the water with a floating crane. Each unit also had to have ample stability when afloat. The unit caissons were thus designed with a width of 24½ft, a length of 36ft and a height of 19½ft ; the total weight of each unit was 180 tons. With them, it was possible to assemble caissons of any length and with widths of 24½ft, 36ft and 49ft. Standard sections were also designed for increasing the height of the caissons. For the construction of these "unit" caissons, a combination of seven firms of contractors was set up ; in Amsterdam, Rotterdam and near Breda four building sites were organised. In a few months, 696 units were built, involving the use of 30,000 cubic yards of concrete and 4900 tons of steel. The caissons were towed from the building sites to the various gaps.

Iron and Steel Institute.—The eighty-fifth annual general meeting of the Iron and Steel Institute will be held in London on Wednesday and Thursday, May 26th and 27th. The first session of the meeting will begin at 9.45 a.m. on Wednesday, May 26th, at the Royal Institution of Great Britain, 21, Albemarle Street, W.1, when, after the formal business and the presentation of the Institute's medals and prizes, the Honourable R. G. Lyttelton will be inducted as president and will deliver his address. Following the presidential address, at 11.30 a.m., Dr. T. P. Colclough will give the seventh Hatfield Memorial Lecture, which is entitled "Development in the Iron and Steel Industry in Great Britain During the Last Twenty-Five Years." Further sessions of the meeting, at 2.30 p.m. on Wednesday, May 26th, and at 10 a.m. and 2.15 p.m. on Thursday, May 27th, for the presentation and discussion of technical papers, will be held at the Institute's offices, 4, Grosvenor Gardens, S.W.1. The Institute's annual dinner will be held at Grosvenor House, Park Lane, W.1, on Wednesday evening, May 26th, at 7 p.m. for 7.30 p.m.

Industrial and Labour Notes

Employment and Unemployment

The Ministry of Labour's latest report on the employment situation in Great Britain shows that during March the total working population declined by 24,000 and at the end of the month totalled 23,441,000 (15,910,000 men and 7,531,000 women). There were more people in civil employment, however, the total at the end of March being 22,283,000 (14,885,000 men and 7,398,000 women).

An analysis of the civil employment figures reveals that the increase in March occurred for the most part in building and contracting, which industries added 15,000 to their labour forces, making a total of 1,411,000. Employment in the country's basic industries showed little variation during March, the total at the end of the month, 3,982,000, being slightly below the figure returned for February. There were fewer people at work in the manufacturing industries during March, the total at the end of the month being 8,954,000. In this category, the number employed in "engineering, metal goods and precision instruments" was 2,612,000, the same as in February.

Unemployment figures included in the Ministry's report relate to April 12th, when there were 316,585 people registered as out of work, compared with 342,866 on March 15th. The Ministry says that the improvement indicated by the April figure was spread over all the main groups of industries, but was most marked in building and contracting and in the hotel and catering trades. The unemployment figure of 316,585 represented about 1·5 per cent of the estimated total number of employees. It included 13,506 who were described as "temporarily stopped."

Engineering Wages

The subject of engineering wages has again been under discussion by the Amalgamated Engineering Union at the annual conference of its national committee, which has been held at Blackpool during the past fortnight. The debate on wages took place on Wednesday of last week, when one resolution before the conference urged that application should be made for a 10 per cent increase on existing wage rates. Other proposals were that a minimum rate of £9 a week for skilled workers and £7 10s. a week for unskilled workers should be demanded. There was submitted to the national committee, however, the draft of a new wages structure for the engineering industry. It proposes a minimum of £8 10s. 4d. a week for "special skills" and four other grades below that figure down to a minimum of £6 18s. 4d. for labourers. After debate, the national committee decided to instruct the union's executive to apply immediately for the new wages structure to be put into effect.

"What the T.U.C. is Doing"

This week the Trades Union Congress, following its custom in previous years, has issued a pamphlet entitled *What the T.U.C. is Doing*. For the most part the pamphlet records the activities of the T.U.C. general council in the period since the annual congress last September. It emphasises that keener competition in world markets is already a challenge to British industry to be "up and doing" in making the best use of machines and materials and the skill and adaptability of its people. Trade unionists, the pamphlet adds, "cannot afford inefficient production in industry." Above all, it is urged, trade unionists must not be narrow-minded in the quest for higher output. Work study and all the other modern techniques are important, the pamphlet says, but "they are not the beginning and end of the struggle." As well as getting the best out of plant, equipment, materials and manpower, which work study seeks to do, industry must plan ahead.

One chapter of the pamphlet is concerned with the T.U.C.'s views on the public control of industry. It recalls the recommendations on public ownership which were approved at last year's Congress, but says that these recommendations were by no means intended to be the last word. Last year's Congress agreed that "closer scrutiny must be given to the ground to be covered before detailed and final decisions could be taken." The pamphlet goes on to say that higher exports, higher productivity and more efficient use of the nation's resources all mean more capital investment to furnish industry with the modern machinery and equipment to earn Britain a living. That, in turn, it is observed, largely depends upon the engineering industries being up to date in their methods. Last September, the pamphlet continues, delegates to the annual congress were promised that the general council would initiate further talks with engineering unions on the future of various sectors of the engineering industry. An invitation to the Confederation of Shipbuilding and Engineering Unions to meet T.U.C. representatives was sent in October. "It has not been our practice," the pamphlet then says, "to go ahead with the fashioning of schemes for the reorganisation of industries without the aid and advice of the unions whose members are employed in them, but up to the time of going to press, no response to the invitation had come our way."

Export Selling

The National General Export Merchants' Group has just published a booklet entitled *Export Selling*. The group consists of the export groups of the London, Birmingham, Liverpool, Manchester and Glasgow Chambers of Commerce, and was formed in 1940, at the suggestion of the Board of Trade, with the object of stimulating this country's exports. The booklet claims that the lion's share of Britain's export trade is conducted by merchants who, it is stated, are first and foremost market experts with knowledge of the buyers' needs, and who can advise the manufacturer accordingly.

The booklet points out that essentially the export merchant seeks out a demand in an overseas market, finds suppliers, often advises on special requirements from his experience and knowledge, and fosters and develops the market for the goods. He takes responsibility for financing and carrying through the entire transaction from the time the goods arrive at the port of shipment. This responsibility includes, of course, the work of handling the shipping, marine insurance, exchange control regulations, consular requirements and other documentation.

Copies of the booklet are available from the National General Export Merchants' Group, 69, Cannon Street, London, E.C.4.

Overseas Civil Engineering Contracts

Some observations on building and civil engineering work in overseas countries are made by Mr. Francis Taylor, chairman of Taylor Woodrow, Ltd., in a statement accompanying the annual report and accounts. Such work, he says, not only benefits the countries in which development is taking place; it gives also an exceptional lift to the export market at home.

Mr. Taylor points out that, directly a major civil engineering project is under way, extensive calls are made for steel, cement, paint and the hundred and one items required to complete the task. Furthermore, the employment of local labour increases the spending power of inhabitants. The project on completion benefits the economic resources of the country where it is installed, the standard of living is raised, and there comes a demand for consumer goods, making further demands on home markets. The commercial risk in carrying out these undertakings, Mr. Taylor comments, is invariably borne by the contractor, though the benefits are shared by many. In frequent journeys about the world, Mr. Taylor says, he is becoming increasingly aware of competition from Continental contractors, and it is evident that they are making bids—which are being accepted—for works at prices known to be well below the true value of the costs.

In Mr. Taylor's opinion that is made possible by help from their respective governments in the shape of tax relief or other concessions. In assisting such undertakings, the statement continues, it may well be that the governments of the countries concerned do not overlook the economic and export advantages to be gained by having their contractors employed overseas. Mr. Taylor expresses the hope that this point may not entirely escape those in authority in this country, and that something will be done to allow British contractors to compete in world markets under conditions no less favourable than those enjoyed by their foreign competitors.

Coal and the Steel Industry

The implications for the steel industry of the recent increases in the price of coal are referred to by the British Iron and Steel Federation in the latest issue of its *Monthly Statistical Bulletin*. It says that the steel industry is the country's biggest consumer of energy and that fuel costs account for about one-fifth of the price of a heavy steel product. Last year, the steel industry's direct coal purchases amounted to almost 21,000,000 tons, out of a total of nearly 208 million tons of inland sales. In addition, the steel industry purchased about 3,500,000 tons of coke, besides large amounts of electricity and gas.

Of the 21,000,000 tons of coal purchased last year by the iron and steel industry, roughly two-thirds was for coking purposes. Improvements in blast furnace efficiency—by ore preparation and various other means—have reduced the coking coal requirement per ton of steel-making iron from 37·6 cwt in 1945 to 34·4 cwt last year. This, the *Bulletin* says, represented a saving of well over 1,000,000 tons of coal in 1953. Nevertheless, the steel industry purchased about 14,000,000 tons of coal for its own coke ovens and will require more during the current year. Since the average price increase on these coals is estimated at 3s. 8d. a ton, the additional burden on the steelmakers is over £2,500,000 a year on the 1953 rate of operations. About 70 per cent of the industry's requirements of blast furnace coke is provided from its own ovens, but the remainder is purchased, mostly from the National Coal Board. The increase here, it is thought, is likely to add a further £1,000,000 to the steel industry's fuel bill. The steel works also use coal for gas producers, boilers, furnaces, locomotives and other purposes.

The *Bulletin* says that, on the basis of the rough overall calculations which have been made, it appears that the latest rise in coal prices will represent a direct addition of about £4,500,000 a year, and more as the quantity purchased goes up. There may also be indirect effects as the higher fuel costs work their way through the economy. One significant factor to which the *Bulletin* draws attention is the difference in the extent of the increase in coal prices in the various districts. It means, of course, that the contribution to be made by the different steelmakers will vary considerably from district to district. Those buying their coal in Scotland, Durham and South Wales will be hardest hit. In the area most affected (Scotland), the *Bulletin* states, iron-making costs are expected to rise by roughly 11s. a ton, whilst in the district least affected (Lincolnshire) the increase will be of the order of 2s. 6d. a ton. These increased charges will be reflected, of course, in steel-making costs: but, the *Bulletin* adds, there is an additional complication in that the ratio of pig iron and scrap in steel-making varies considerably from district to district.

Notes and Memoranda

Air and Water

BELGIAN AIR FORCE ORDERS BRITISH HELICOPTERS.—A number of Mark 4 Bristol "Sycamore" helicopters has been ordered from the Bristol Aeroplane Company by the Belgian Air Force, which will use the aircraft mainly for ambulance and rescue operations in the Belgian Congo.

DRY DOCK OWNERS' AND REPAIRERS' CENTRAL COUNCIL.—At the annual meeting of the Dry Dock Owners' and Repairers' Central Council, held in Edinburgh on Thursday of last week, Mr. A. C. Waddy, a director of William Gray and Co., Ltd., was elected chairman for the year. At the same meeting Engineer - Captain G. Villar, R.N. (Retd.), a director of John I. Thornycroft and Co., Ltd., was appointed senior vice-chairman and Mr. P. Gifford, a director of D. and W. Henderson, Ltd., was appointed junior vice-chairman.

IMPROVEMENTS AT IMMINGHAM DOCK.—The Docks and Inland Waterways Board of Management has announced that, with the approval of the British Transport Commission, new coaling appliances are to be installed at Immingham Dock at an estimated cost of £800,000. The scheme provides for the replacement of three of the existing coal hoists at the South Quay, which will include a rotary side tippler, conveyor belt and hinged radial conveyor. The tippler will be capable of dealing with high capacity coal wagons. A telescopic delivery belt will vary the outreach from the quay face so as to distribute coal in the holds of vessels. Last year over 3,000,000 tons of coal—principally from the East Midlands coalfield—were shipped foreign or coastwise through Immingham Dock.

FLEET ATTENDANT OIL TANKERS.—The oil tanker "Eddyness," built by the Blyth Dry Dock and Shipbuilding Company, Ltd., is the eighth and last of the Fleet Attendant vessels built for the Admiralty. These ships carry about 2000 tons deadweight at moderate draught in the following dimensions: length between perpendiculars, 270ft.; breadth moulded, 44ft; and depth moulded, 18ft 6in. Construction of the ships has been shared between the Caledon Shipbuilding and Engineering Company, Ltd., the Blythswood Shipbuilding and Engineering Company, Ltd., Lobnitz and Co., Ltd., and the Blyth Dry Dock and Shipbuilding Company, Ltd. Lobnitz and Co., Ltd., has built the main machinery, consisting of a set of steam triple-expansion engines, for all the ships of the class.

AERODROMES AND AGRICULTURE.—At a recent meeting of the Farmers' Club, Sir Harold Wernher, chairman of the National Institute of Agricultural Engineering, presented a paper entitled "An Industrialist looks at Farm Machinery." In the course of it, Sir Harold spoke of the heavy demands made upon agriculture by civil and military aerodromes, saying that airports which were adequate ten years ago were now too small to be extended, or else had to increase their present area to cope with the larger volume of traffic and speed of aircraft requiring longer runways. Sir Harold urged that the time had arrived for a survey to be made of all the airports in this country and of the possible civil and strategic requirements for the future. It should be possible, he said, with modern landing devices, to increase the traffic capacity at the main airports and, so far as internal domestic air travel was concerned, the future must lie with the helicopter, in which case landing facilities within the towns would provide the solution. The result of an investigation such as that which he suggested, Sir Harold observed, might well indicate the transfer back to farming of many acres of land.

Miscellanea

BRITISH STEEL FOUNDERS' ASSOCIATION.—At the recent annual meeting of the British Steel Founders' Association, Mr. F. N. Lloyd, chairman and managing director of F. H. Lloyd and Co., Ltd., was elected chairman. In that office, he succeeds Mr. T. H. Summerson, to whom a presentation was made at the meeting.

IRON AND STEEL PRODUCTION.—Steel production in Great Britain during the month of April averaged 368,400 tons a week and was thus at an annual rate of 19,155,000 tons, which is the highest so far recorded. This production rate was achieved despite the Easter holiday period which affected certain districts. Pig iron output in April averaged 232,100 tons a week, which represents an annual production rate of 12,069,000 tons.

SCHOOL FOR SERVICE ENGINEERS.—A school for customers' engineers has been opened by Petters, Ltd., service division at Burton-on-the-Wolds, near Loughborough. The first classes started on April 26th, to be followed by others on July 19th and September 6th. The curriculum includes the stripping and rebuilding of new engines, and lectures by experts from firms supplying lubricating oils, fuel injection equipment, and so on.

HAMBURG REFINERY.—At the B.P. Hamburg refinery of the Anglo-Iranian Oil Company, Ltd., a new combined atmospheric and vacuum distillation unit has been commissioned and has raised the group's refining capacity in Germany to 1,440,000 tons a year, representing 1,240,000 tons from the B.P. Hamburg Refinery, compared with 700,000 tons last year, and 200,000 tons from the Schindler refinery.

SCOTTISH INDUSTRIES EXHIBITION.—The second Scottish Industries Exhibition is to be held at Kelvin Hall, Glasgow, from September 2nd till September 18th next. The last exhibition was held in 1949 and since then the basic industries in Scotland have extended considerably, as some 500 new factories or major factory expansions have begun production. The exhibition will cover many industries, including textiles, shipbuilding, engineering, chemicals, foodstuffs, furniture, pottery, &c.

ROYAL AGRICULTURAL SOCIETY.—The Royal Agricultural Society has stated that the accounts for last year's Royal Show at Blackpool reveal a deficit of £3945, despite the fact that a record local fund was raised. The total cost of staging the show was £158,390, the actual erection costs being £16,000 higher than those incurred at Newton Abbot in 1952. The Duke of Rutland has been nominated as president of the Society for 1955, in which year the Royal Show is to be held at Nottingham.

SYNTHETIC RESIN PLANT.—Monsanto Chemicals, Ltd., announces that it has recently completed construction of a tonnage-scale pilot plant from which a range of styrene-butadiene rubber-like resins will be available from July of this year. A sum in the region of £500,000 is also to be expended on a large-scale plant which will commence production in approximately two years, with a planned initial capacity of 4000 tons per annum of these materials.

SHELL MOULDING MACHINES.—In our issue of December 25, 1953, the double-oven shell moulding machine developed by Fairbairn Lawson Combe Barbour, Ltd., of Leeds, was described in some detail. As a further development of this machine the firm has now introduced a single-oven, semi-automatic machine built on similar lines and having a capacity of from fifty to sixty moulds per hour. This machine is designed for use with 24in by 16in pattern plates having a maximum depth of 4in. It is fitted with an automatic dump box rotating mechanism and its single gas oven is thermostatically controlled.

NEWCOMEN SOCIETY'S SUMMER MEETING.—The summer meeting of the Newcomen Society is to be held in Cornwall, with headquarters at Falmouth, from May 26th to 29th. The programme includes the inspection of a number of beam engines, about the preservation of which the Cornish Engines Preservation Society is actively concerned. Visits will also be made to the Holman Museum at Camborne, and to Trevithick's cottage and museum at Penponds. The annual dinner of the Newcomen Society will be held at the Falmouth Hotel on Thursday evening, May 27th. After it, a talk on "Cornish Mining History" will be given by Mr. A. K. Hamilton Jenkin.

COAL OUTPUT.—Coal output in the week ended May 8th totalled 4,435,100 tons, which was about 2000 tons below the output in the comparable week of last year. The deep-mined output, however, last week, at 4,230,900 tons, was higher than in the week ended May 9, 1953. The Ministry of Fuel and Power says that in the first eighteen weeks of this year output totalled 81,077,900 tons, of which 77,358,700 tons came from deep mines and 3,719,200 tons from opencast. In the corresponding period of last year the total amount of coal gained was 81,253,500 tons, the deep-mined output being 77,316,700 tons, and that from opencast workings being 3,936,800 tons. Total distributed coal stocks on May 1st were 12,934,000 tons, compared with 12,812,000 tons a year earlier.

METAL SCAFFOLDING.—The latest addition to the Ministry of Works series of advisory leaflets is entitled *Metal Scaffolding*, and is intended mainly to help small builders and others who wish to erect their own scaffolding or hired components. It deals with simple forms of putlog and independent scaffolds for house building and maintenance work up to three or four storeys. A typical scaffold of each kind is illustrated to show how the various components are assembled and how bracing should be carried out when this is necessary. Information is given on materials used for scaffolding, spacing of standards and working platforms. Attention is drawn to the importance of tying-in and inspection, and there is a useful summary of "Points to Remember." Copies of the leaflet (No. 36) are obtainable from H.M. Stationery Office, price 3d.

PRODUCTIVITY IN THE PRESSED METAL INDUSTRY.—The British Productivity Council has published another review in a series of surveys of British industries which sent productivity teams to the U.S.A. under the auspices of the Anglo-American Council on Productivity. It deals with the pressed metal industry, a productivity team from which visited America in 1949 and issued its report the following year. In 1951 a productivity team representing the American pressed metal industry paid a return visit to the United Kingdom to study production methods here, and that team's report was also published by the Council. The present review points out that the British pressed metal industry is particularly important, in that many of the component parts it produces are for some of this country's most remunerative exports. Until last year the industry was severely handicapped by the shortage of raw materials, which prevented modern production techniques being adopted on a wide scale, particularly by the smaller firms. With the easing of the supply position, however, many factories have reorganised their production methods, and the review urges that greater attention should be paid to standardisation and simplification, although it is recognised that in many instances it is the producer of the finished article and not the pressed metal producer who decides policy on this particular point. It is felt, moreover, that more attention should be paid to detailed cost analysis with a view to reducing wastage and to pin-pointing deficiencies within the factory. Among other subjects dealt with in the review are materials handling, plant layout, safety measures, new techniques, and labour conditions. Details are also given of the individual efforts made by thirteen different firms to increase their productivity. The review is available, price 2s., from the British Productivity Council, 21, Tothill Street, London, S.W.1.

Personal and Business

MR. C. F. BARNARD has been appointed joint managing director of Associated British Oil Engines (Marine), Ltd.

PERCIVAL AIRCRAFT, Ltd., Luton Airport, Bedfordshire, will in future be known as Hunting Percival Aircraft, Ltd.

MR. RONALD C. PRICE has been appointed press officer of The Villiers Engineering Company, Ltd., Wolverhampton.

SIR HENRY WILSON SMITH, K.C.B., has been appointed deputy chairman of Powell Duffryn, Ltd., 19, Berkeley Street, London, W.1.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., announces the appointment of Mr. J. E. Sutton as senior lamp and lighting salesman at the Newcastle upon Tyne office.

THE PARSONS ENGINEERING COMPANY, Ltd., has moved its London office to 9 and 10, Cavendish Square, W.1 (telephone, Langham 8351; telegrams, "Asbriteng, Wesdo, London").

MR. J. R. C. BOYCE has been elected president of the British Oil Burner Manufacturers' Association, Ltd., and Mr. J. D. Fitzgerald and Mr. F. C. Pillinger have been elected vice-presidents.

A. REYROLLE AND CO., Ltd., Hebburn, Co. Durham, has moved its Leeds office to 20–22, St. Paul's Street, Leeds, 1. The office continues under the control of Mr. A. J. Coveney, M.I.E.E.

ASSOCIATED BRITISH ENGINEERING, Ltd., has transferred its registered office to 9 and 10, Cavendish Square, London, W.1 (telephone, Langham 8351; telegrams, "Asbriteng, Wesdo, London").

RHODES, BRYDON AND YOUATT, Ltd., Stockport, announces the appointment of Mr. J. Richmond as London manager. Mr. C. W. Haydon has been appointed technical representative in the London area.

THE BRITISH OXYGEN COMPANY, Ltd., Bridgewater House, Cleveland Row, London, S.W.1, states that Mr. R. J. Foster has been appointed liaison officer for the aircraft industry, the services and Government departments.

THE BRITISH ALUMINIUM COMPANY, Ltd., states that Mr. George Boex will retire from his position as joint managing director on July 4th, and will be succeeded by Mr. W. J. Thomas. Mr. Boex will remain a director of the company.

MR. W. A. BABINGTON, who has been editor of *Lloyd's List and Shipping Gazette* since 1946, has retired from the service of the Corporation of Lloyd's and has been succeeded by Mr. G. J. Bryant, who has been the chief reporter since 1936.

PENISTONE HARDMETALS COMPANY, Ltd., and PENISTONE HIGH SPEED STEEL TOOLS COMPANY, Ltd., Rudyard Road, Sheffield, 6, have appointed Angus and Crichton (Sales), Ltd., 203, West George Street, Glasgow, as their sole agent for Scotland.

LLOYD'S REGISTER OF SHIPPING announces the retirement on June 30th of Mr. H. A. Garnett, principal surveyor for Australia. He has been in the Society's service since 1919. Mr. B. P. Fielden has been appointed to succeed Mr. Garnett.

MR. V. J. FAULKNER, publicity manager of Crompton Parkinson, Ltd., has been elected chairman of the BEAMA publicity committee. Mr. C. H. Alsop, publicity manager of W. H. Allen, Sons and Co., Ltd., has been elected vice-chairman.

THE INTERNATIONAL NICKEL COMPANY OF CANADA, Ltd., states that Mr. R. D. Parker has succeeded Mr. J. Roy Gordon as general manager of Canadian operations. Mr. Gordon, who is a director of the company, has moved from Copper Cliff to New York City.

DR. BASIL F. J. SCHONLAND, head of the Bernard Price Institute of Geophysical Research in the University of Witwatersrand, is to become deputy director of the Atomic Energy Research Establishment at Harwell. The Department of Atomic Energy announces that this appointment will take effect towards the end of this year.

WICKMAN, Ltd., Coventry, announces the appointment of Mr. G. C. Bateman as direct factory representative in the United Kingdom and other countries for Lidkopings Mekaniska Verkstads, A.B., Lidkoping, Sweden, and Ulsvunda Verkstader, A.B., Stockholm. Mr. B. Heaven has been appointed as United Kingdom sales specialist of Wickman, Ltd., for Lidkoping centreless grinding machines and U.V.A. internal grinding machines.

Contracts

THE CLAN LINE STEAMERS, Ltd., has ordered from the Marconi International Marine Communication Company, Ltd., twenty-four marine radar installations to be fitted to twenty-four ships of the line.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd. Trafford Park, Manchester, has received a contract worth £4,750,000 for the supply of diesel-electric locomotives to Coras Iompair Eireann (Irish State Transport). It is said to be the largest order for diesel locomotives ever placed in Britain. Ninety-four locomotives are to be supplied, sixty of the 1200 h.p. six-axle class, and thirty-four of the 550 h.p. four-axle class. The electric equipments will be manufactured by Metropolitan-Vickers at Manchester and Sheffield, the diesel engines by Crossley Brothers, Ltd., Manchester, and the mechanical parts by Metropolitan-Cammell, Carriage and Wagon Company, Ltd., Birmingham.

British Patent Specifications

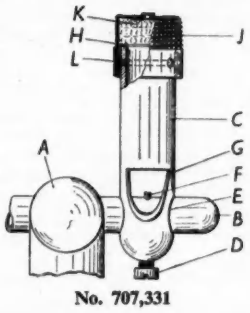
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

GAS BURNERS

707,331. March 6, 1952.—BUNSEN BURNERS, Hans Vaillant, 40, Berghauserstrasse Remscheid, Germany, trading as Joh. Vaillant K.G. (*Inventors: Hans Donges and Fritz Konig.*)

The invention relates to gas burners of the Bunsen type, in particular to propane gas burners for gas water heaters with vertical mixing tubes. The burner consists of a pipe *A*, which is connected to the gas supply mains, and of several distributor pipes *B*,



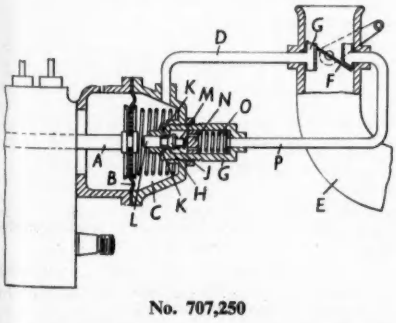
No. 707,331

each of which carries several mixing tubes *C*. The mixing tube is closed at the lower end. An increase of thickness of material is produced by shaping and a tapped hole is made in the closed end to receive a screw *D*. The ends of the distributor *B* are also closed. The mixing tube *C* is pushed sideways on to the distributor pipe before the screw *D* is screwed in. The upper end of the screw is formed as a gas nozzle *F* and projects into the mixing tube. The axial bore of the nozzle communicates inside the distributor pipe *B* with a transverse bore opening into the distributor pipe. The mixing tube *C* is cut open at both sides parallel to the distributor pipe *B*, thus forming two large air entrance orifices *G* of substantially triangular shape. The nozzle *F* is placed nearly in line with the centres of the air entrance orifices *G*, so that the primary air is smoothly drawn in from below. At the head of the mixing tube a U-sectioned ring *H* is provided, into which the rim of an inverted cup-shaped body *J* of wire gauze is inserted. The bottom of the gauze is covered by a flame deflector disc *K*, so that the gas mixture escapes only at the cylindrical periphery of the gauze. The ring *H* together with the gauze is fastened by pressing depressions *L* in the ring and, with it, the gauze into an annular groove in the mixing tube. It is possible to cover different zones of the wire gauze body so that the supply of secondary air is improved. Such a covering of the gas mixture exit surface can be effected, for example, by crossed tapes stretched over the gauze.—*April* 14, 1954.

INTERNAL COMBUSTION ENGINES

707,250. July 11, 1951.—SPEED GOVERNORS FOR FUEL INJECTION PUMPS, C.A.V., Ltd., Warple Way, Acton, London, W.3. (*Inventor: Wilfrid Edward Walter Nicolls.*)

Referring to the drawing, there is connected to one end of a sliding bar *A*, which controls the output of the pump, a spring-loaded flexible diaphragm *B*

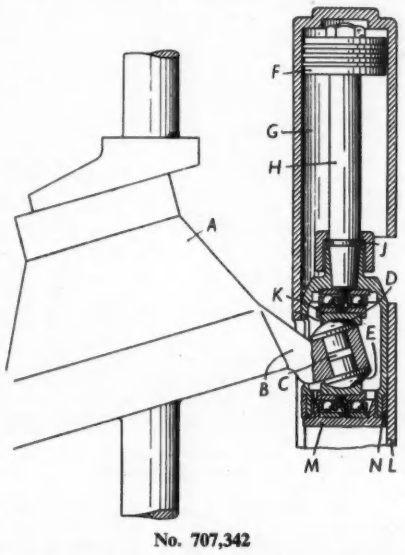


No. 707,250

forming one side of a chamber *C*. Instead of a diaphragm, a piston may be provided. The chamber *C* is connected by a pipe *D* with the engine manifold *E* at the engine side of a throttle *F* of the butterfly type. Alternatively, the pipe may be connected to a short venturi tube *G* arranged as shown. In the end wall of the chamber *C* remote from the diaphragm is secured one end of a relatively small and coaxially arranged hollow cylinder *G* within which is provided a seating *H* for a closure member *J* which controls a passage or passages *K* leading from the cylinder to the chamber. The closure member *J* is formed on the inner end of a stem *L* slidable through the end of the cylinder and moving in the direction for opening the passage *K* by the diaphragm. The closure member is loaded by a relatively light and short spring *M*, which at its end remote from the closure member is supported by one side of a freely movable abutment *N* in the chamber, the abutment having holes therein as shown to provide free communication between the parts of the cylinder at its opposite sides. The other side of the abutment is acted on by a relatively strong spring *O*, which at its rear end is supported by a fixed or adjustable abutment in the cylinder. The end of the cylinder *G* remote from the closure member is connected by a pipe *P* to the manifold at the inlet side of the throttle. Alternatively, the pipe may be connected to a port in the manifold, which is controlled by a rotary valve movable by the throttle as described in Specification No. 697,806. The action of the stabiliser is such that at low speeds, when the throttle is closed, the diaphragm *B* moves the closure member *J* off its seating and so allows air at atmospheric pressure to bleed into the chamber *C*. In this action only the light spring *M* is operative. At high speeds under light load conditions and with the throttle open the closure member is moved by the diaphragm sufficiently to effect contact between the closure member and the free abutment *N*. The required damping of the diaphragm *B* is then effected by the relatively strong spring *O*, the atmospheric air bleed being ineffective when the throttle is open. By this invention stabilising of the governor over a range of speed variations can be effected in a very simple and convenient manner.—*April* 14, 1954.

707,342. April 10, 1952.—SWASH PLATE DRIVING GEARS, N.V. Philips' Gloeilampenfabrieken, Emmasingel 29, Eindhoven, Holland.

As shown in the drawing, a reciprocating engine comprises a swash plate *A* pivotally mounted on a shaft. The swash plate has a radial arm *B*, which is furnished with a bore *C* engaged by two pivots *D* and *E*. A piston *F* is movable in a cylinder *G*, which may be a cylinder of a steam, hot gas or internal combustion engine, a compressor, refrigerator or heat pump. The piston *F* has a piston-rod *H* comprising a collar *J* on which is fitted a nut which is screwed on to a cylindrical housing *K* in a cylindrical guide *L*. A ball thrust plate is centrally arranged in the housing



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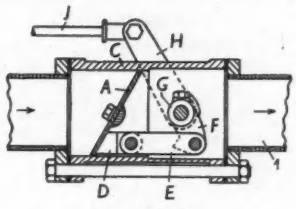
K. The pivots *D* and *E* are movable in step bearings forming part of ball thrust plates. Ball bearings are provided between plates on the step bearings and plates in the housing. The assembly of pivots, step bearings, plates, ball bearings, and thrust plates is enclosed in the housing by means of a nut *M*, a spacing member *N* permitting correct adjustment of the nut. In the case of wear the spacing member is slightly reduced in size. The balls are moved in a constrained manner by means of pins and collars so that the ball bearings move at a lower speed than the step bearings.—*April* 14, 1954.

707,438. July 11, 1952.—EXHAUST BRAKING DEVICES FOR SPARK-IGNITION AND COMPRESSION-IGNITION Engines, Oetiker-Motorbremsen A.G., 22, Bristenstrasse, Zürich, Switzerland.

The invention relates to brakes for internal combustion engines which have means for substantially closing the engine exhaust duct, thus preventing the flow of exhaust gas from the engine. Referring to the drawing the exhaust brake is shown arranged in a motor lorry engine exhaust pipe, in which the exhaust gases are under greater than atmospheric pressure. A valve *A* is mounted in bearings in the wall of a duct section *C* in the exhaust pipe. The bearing members are freely journalled so that the exhaust gases can flow freely round them and deposits are reduced to small proportions. A linkage arm *D* is secured to the valve *A* on its exhaust side. A push-pull rod *E* is pivoted to the arm and at its free end is pivoted to an actuating arm *F* fixed to a sleeve *G*. The sleeve is fixed, by means of a screw, on a shaft



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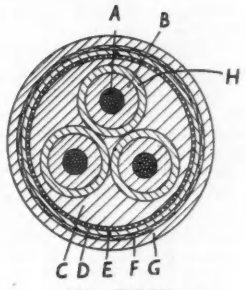
and an actuating lever *H* is fixed to the arm *F* outside the wall and is connected by a member *J*, which may be pushed or pulled by the engine attendant or vehicle driver to open or close the valve *A*. In the case of a motor vehicle the link *J* is connected to means in the driver's cab for operating the brake. In operation the valve *A* is shut to close the duct section *C*, thus braking the engine by creating a back pressure and slowing it down or even stopping it. The gases flow through the duct section and pipe, escape of gases from the duct section through the bearings is prevented, while the bearing members *B*, being freely journalled permit easy actuation of the valve.—*April* 14, 1954.

ELECTRICAL ENGINEERING

705,540. April 9, 1952.—MULTI-CORE ELECTRIC CABLES, Siemens Schuckertwerke A.G., Berlin and Erlangen, Germany.

This invention relates to cable installations for supplying current to coal-cutting machines, travelling transformers in underground mine workings and the like. As shown in the drawing, the main conductors *A* are provided with an insulation *B* of rubber or synthetic rubberlike material with a common internal insulating jacket *C*. The earth conductor *D* is arranged over the jacket. Over the earth conductor



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is an insulating covering *E*, over which a conductive screen *F* is located. The external covering is formed by a protective jacket *G*, which consists of natural or synthetic rubber. The earth conductor *D* may be applied in the form of individual wires with a short or long lay or it may be constructed as a mesh consisting of relatively thick wires, or may be constructed of narrow strips of copper, bronze or other highly flexible metals. If the cable is intended for operation at high voltage, it is advisable to protect the core insulation from the action of ozone, this method of protection by means of a layer of ozone-resisting material *H* being also described in the specification.—*March*, 17 1954.

METALLURGY

707,276. July 11, 1952.—THE LAPPING OF METAL SURFACES, The Pyrene Company, Ltd., Great West Road, Brentford, Middlesex.

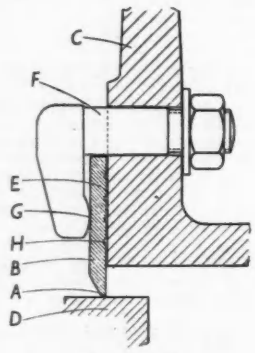
According to the invention, the surfaces to be lapped are moved in contact with one another in the presence of a solution which attacks or coats at least one of them. The solution may be acidic or alkaline. Grinding powder may also be used. The solution is preferably a phosphate coating solution, particularly if one or both of the surfaces to be lapped is or are made of cast iron. If a cast iron surface is to be lapped against a steel surface, it is enough if the solution attacks the cast iron. Particularly good results are obtained if one or both of the surfaces is coated with phosphate before the lapping begins. One phosphate coating solution in which cast iron surfaces

may be immersed during the lapping process contains, per litre, 19·5 grammes of zinc, 23 grammes of P_2O_5 and 24·5 grammes of NO_3. A wetting agent may advantageously be added to this solution to facilitate its penetration between the surfaces. If a grinding powder is used, the solution is preferably changed before the lapping is complete, being replaced by a powder-free solution for the final stage. When aluminium articles are being lapped, a phosphate solution of the kind capable of coating aluminium may be used, or, instead, a solution of the kind often used for coating aluminium and containing sodium chromate and sodium carbonate.—*April* 14, 1954.

FURNACES

707,274. June 30, 1952.—DOORS FOR COKE OVENS, G. Wolff, Jr., G.m.b.H., Bochum-Linden, Germany.

The invention relates to doors for coke ovens and the like, of the kind which are provided with sealing bands which embrace the body of the door and are provided with a knife edge which bears on the door frame of an oven chamber. Referring



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to the drawing, a gas-tight sealing of the door opening is made effective by causing the knife edge *A* of a sealing band *B*, which embraces the door *C*, to press against the flat outer surface of the door frame *D*. The sealing band is held to the bearing surface *E* of the body of the door by friction between the band and the surface, and is pressed against the surface by bolts *F*. The bolts have hook projections which are provided with pads *G* and by tightening nuts the bolts hold the band *B* firmly to the door so that it will follow the movements of the door when the door is closed tightly, but will, nevertheless, permit the position of the band on the door to be adjusted locally if the rear edge of the band is struck by a hammer or other tool. Thus, when a door has been closed in the usual manner and the knife edge *A* has been caused to bear firmly on the frame *D*, it may occur that adequate sealing has not been effected at one or more points along the perimeter of the band. In such case, the rear edge of the band behind the points of gas escape is struck until an effective seal is obtained. The sealing band shown in the drawing is made from a rolled bar by drawing. This operation hardens the faces of the knife edge *A* so that it is able to resist damage by cleaning tools. During the drawing operation, longitudinally extending grooves *H* are produced and these grooves result in a labyrinth-like seal being provided between the band and the door surface.—*April* 14, 1954.

Launches and Trial Trips

ELPENOR, cargo and passenger liner ; built by Harland and Wolff, Ltd., at Belfast for Alfred Holt and Co. ; length overall 485ft, length between perpendiculars 452ft 9in, breadth moulded 62ft, depth moulded 35ft ; twelve passengers ; two complete steel decks, four main cargo holds and one deep tank, derrick complement includes one to lift 50 tons, electric deck machinery ; three 220kW diesel-driven generators, one Cochran auxiliary boiler ; Harland-B. and W. two cycle, single-acting oil engine, seven cylinders, 750mm diameter by 2000mm combined stroke, 107 r.p.m.—Trial, April 22nd.

SOLSTEN, oil tanker ; built by Barclay Curle and Co., Ltd., for Rafen and Loennechen, Norway ; length 528ft, breadth 65ft 6in, depth 37ft 6in, deadweight 15,200 tons, ten cargo tanks, two pump rooms ; two 75kW steam-driven generators, two cylindrical multitubular boilers ; Barclay Curle-Doxford oil engine, five cylinders, 670mm diameter by 2320mm combined stroke. —Launch, April 23rd.

TOREADOR, cargo ship ; built by the Netherlands Dock and Shipbuilding Company for Wilh. Wilhelmsen, Oslo ; length between perpendiculars 134m, breadth moulded 18·76m, depth moulded 12·49m, deadweight 8680 tons on 7·80m draught ; twelve passengers ; five holds, one 25-ton, four 10-ton, nine 5-ton and six 3-ton derricks, electrical deck machinery, three 200kW diesel-driven generators and one 120kW steam-driven generator ; N.D.S.M.-Doxford oil engine, six cylinders, 7500 b.h.p. at 115 r.p.m. ; trial speed 17·4 knots.—Launch, April 24th.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

HOOK SPANNERS, PEG SPANNERS, COUPLING WRENCHES, AND THE RELATED SLOTS, HOLES AND HORNS

No. 2090 : 1954. Price 5s.—The lack of a standard specification for hook (or C) spanners and peg spanners has often given rise to anxiety in various branches of industry, particularly the aircraft field. Special attention has been devoted to the safety aspect, in order to reduce the risk of slip to a minimum when the spanners are used correctly.

ELECTRICAL INDICATING INSTRUMENTS

No. 89 : 1954. Price 7s. 6d.—A new edition of this standard, covering ammeters, voltmeters, wattmeters, frequency indicators, and power factor indicators, has just been published. The last edition was issued in 1937 and in carrying out the present revision opportunity has been taken to bring the specification more into line with present day practice, both in the design and in the use of instruments. At the same time due regard is paid to developments still in progress by deliberately making some requirements, e.g. those relating to construction of scales, not too rigid. The two classes of instruments now recognised are precision instruments and industrial instruments, the former having emphasis on accuracy and the latter on robustness. The specification falls into a number of sections which cover ratings, construction, marking, tests, limits of error and variation of indication. Limits of error are generally expressed as a percentage of scale range, allowance being made for the greater accuracy which one may expect from the instruments having longer scale lengths. Some allowance is made for the different conditions of use between industrial switchboard instruments and industrial portable instruments, and special consideration is given to ammeters which require extended scales to allow for momentary overloads. Tables are given of preferred ranges for ammeters and voltmeters, and of permissible variations in indication due to changes in temperature of the surrounding air, to external magnetic field, change in frequency, to being left in circuit, &c.

The section on marking indicates the information to be given with each instrument, but in order to maintain clarity of scale reading differentiating between that which must be visible from the front and that which must be visible from the outside, but not be obtrusive. Tests are dealt with in detail and include high-voltage tests and damping times. Extensive appendices, while not mandatory, give valuable information on the interpretation of the specification and recommend dimensions of instrument cases, shunts, letter symbols and graphical symbols. As mentioned in the foreword to the specification, the accuracy laid down in the standard does not in any way represent the highest degree of accuracy which can be obtained with British instruments. Greater accuracy can be provided by arrangement with manufacturers, but the limits given in the specification represent good working values to satisfy the general requirements of both manufacturer and user.

Codes of Practice

MECHANICAL VENTILATION

Draft Code 352 (CP (B) 1172 : 1954). Price 12s. 6d. The British Standards Institution has issued as a draft for comment this code on mechanical ventilation, which has been prepared for the council by a joint committee convened by the Institution of Mechanical Engineers and the Institution of Heating and Ventilating Engineers.

The code comprises a head code and seven sub-codes incorporated in one document, the sub-codes having the following titles : Fans, Motors and Starting Gear, Air Heaters, Air Distribution Systems, Air Cleaning Devices, Thermal Insulation, Soundproofing and Anti-vibration Devices, and Temperature and Humidity Controls. The head code, 352, deals with mechanical ventilation in general, whilst the sub-codes cover in detail the subjects indicated in their titles. Cross references to the head code and to other sub-codes are inserted wherever appropriate and some helpful tables, diagrams and charts are also included.

The code gives guidance, at all stages, on the work involved in the general designing, planning and testing of ventilating systems, whereby air is forced into or extracted from buildings. In drafting the code, the committee has assumed : (*a*) that the design of such an installation will be entrusted to a fully qualified engineer, and (*b*) that the execution of the work will be carried out under qualified supervision.

The Code is in draft form and is subject to amendment in the light of comments received, which should be submitted by June 18th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INSTITUTE OF MARINE ENGINEERS

Mon., May 17th.—85, Minories, London, E.C.3, Films "Power for Ships," and "Diesel Power on the River Thames," 6.30 p.m.
Mon., May 31st.—JUNIOR LECTURE : 85, Minories, London, E.C.3, "Watchkeeping and Sea-Going Practice," H. C. Gibson, 6.30 p.m.

INSTITUTE OF NAVIGATION

Fri., May 21st.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Visual Aids to Bad-Weather Approach," E. S. Calvert, 5 p.m.

INSTITUTE OF PETROLEUM

To-day, May 14th.—26, Portland Place, London, W.1, Symposium on Medical Services in the Petroleum Industry, 5.30 p.m.
Wed., May 19th.—Manson House, 26, Portland Place, London, W.1, "Medical Services in the Petroleum Industry," S. D. McClean and F. L. Webster, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 18th.—STRUCTURAL AND BUILDING MEETING : Great George Street, London, S.W.1, "Design and Construction of the Superstructure of the Marshal Carmona Bridge at Vila Franca de Xvia, Portugal," T. J. Upstone and W. Cardno, 5.30 p.m.
Thurs., May 20th.—ROAD MEETING : Great George Street, London, S.W.1, "The Road Surface as a Factor in Street Lighting," A. W. Christie, 5.30 p.m.
Tues., May 25th.—ORDINARY MEETING FOLLOWED BY JOINT MEETING WITH INSTITUTION OF ELECTRICAL ENGINEERS : Great George Street, London, S.W.1, "Owen Falls, Uganda Hydro-Electric Development," C. R. Westlake, T. A. L. Paton and R. W. Mountain, 5.30 p.m.
Wed., May 26th.—Great George Street, London, S.W.1, "Owen Falls : Constructional Problems," D. P. Bertlin and Henry Olivier ; "A Note on 'Model Tests,'" C. M. White, 5.30 p.m.
Thurs., May 27th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Development and Utilisation of Hydro-Electric Power in Uganda," J. M. Stock and J. Lithgow, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., May 17th.—LONDON STUDENTS' SECTION : Savoy Place, London, W.C.2, Annual General Meeting, Film Show, 6.30 p.m.
Tues., May 18th.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Questions Night, 6 p.m.
Thurs., May 20th.—ANNUAL GENERAL MEETING : Savoy Place, London, W.C.2, Corporate Members and Associates only, 5.30 p.m.
Tues., May 25th.—JOINT MEETING : Institution of Civil Engineers, Great George Street, London, S.W.1, "Owen Falls, Uganda Hydro-Electric Development," C. R. Westlake, T. A. L. Paton and R. W. Mountain, 5.30 p.m.
Wed., May 26th.—SUPPLY SECTION : Savoy Place, London, W.C.2, "Electrical Power Demand and Supply in the United States and the Role of Research in the Quarter Century Ahead," Philip Sporn, 5.30 p.m.——NORTH, SOUTH-EAST AND SOUTH-WEST SCOTLAND SUB-CENTRES : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Annual General Meeting : Address by Chairman, C. H. A. Collyns, 7 p.m.
Thurs., May 27th.—ORDINARY MEETING : Savoy Place, London, W.C.2, "Development and Utilisation of Hydro-Electric Power in Uganda," J. M. Stock and J. Lithgow, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, May 14th.—GENERAL MEETING, STEAM GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Rapid Starting Technique : Some Significant Tests at Poole Power Station," J. S. Hall and A. F. Britton, 5.30 p.m.
Mon., May 17th.—MIDLAND GRADUATES' SECTIONS : James Watt Memorial Institute, Great Charles Street, Birmingham, "Brakes," G. J. H. Buss, 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Thurs., May 20th.—WOLVERHAMPTON GRADUATE SECTION : Technical College, Wulfruna Street, Wolverhampton, "The Metallurgists' Place in Production Engineering," E. R. Gadd, 7.30 p.m.
Fri., May 21st.—STOKE-ON-TRENT SECTION : Building Department, Technical College, Cauldon Place, Shelton, Stoke-on-Trent, "Metal Spraying," H. J. Plaster, 7.30 p.m.
Wed., May 26th.—SHREWSBURY SECTION : Technical College, Shrewsbury, "Cutting Tools, Their Development and Application," W. Castledine, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., May 27th.—11, Upper Belgrave Street, London, S.W.1, Annual General Meeting, 5.55 p.m.

IRON AND STEEL INSTITUTE

Wed. and Thurs., May 26th and 27th.—4, Grosvenor Gardens, London, S.W.1, Annual General Meeting, Morning Session on Wednesday in the Lecture Theatre, Royal Institution, Albemarle Street, London, W.1 ; Hatfield Memorial Lecture, "Development in the Iron and Steel Industry in Great Britain During the Last Twenty-five Years," T. P. Colclough, 11.30 a.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., May 20th.—Mining and Technical College, Wigan, "Long Shot Hole Experiments at Reedley Colliery," J. Crossland and T. Whalley, 3.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., May 20th.—Royal Institution, Albemarle Street, London, W.1, Wilbur Wright Memorial Lecture, "The Choice of Power Units for Civil Aeroplanes," A. E. Russell, 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., May 31st.—12, Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Fri., May 21st.—CHEMICAL ENGINEERING GROUP : Hotel Rubens, Buckingham Palace Road, London, S.W.1, Annual General Meeting and Dinner, 6.45 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., May 25th.—MAIN MEETING : Manson House, Portland Place, London, W.1, Annual General Meeting, followed by a "Gadgets" evening, 6 p.m.